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(54) **NAME-BASED ROUTING THROUGH NETWORKS**

(71) Applicant: **Level 3 Communications, LLC**,
Broomfield, CO (US)

(72) Inventors: **David Sutton**, Monroe, LA (US); **Steve Toms**, Middleburg, FL (US); **Shelley Goldner**, Superior, CO (US); **Shelli L. Hurd**, Arvada, CO (US)

(73) Assignee: **Level 3 Communications, LLC**,
Broomfield, CO (US)

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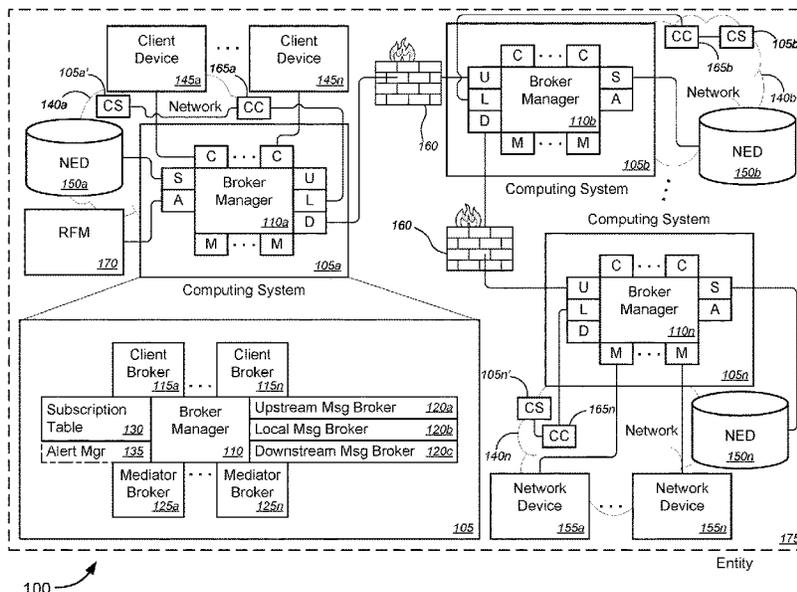
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Primary Examiner — Anthony Mejia

(57) **ABSTRACT**

Novel tools and techniques are provided for implementing name-based routing through networks. In various embodiments, a broker manager in each of a plurality of networks may receive a subscription request for a network device from a client device, each device being locally accessible or disposed in an upstream or downstream network. The broker manager uses its client broker to communicate with a locally accessible client device, and uses its mediator broker (and, sometimes, an intermediate device(s)) to communicate with a locally accessible network device. The broker manager otherwise uses its messaging brokers to communicate with control channels of one or more networks. Once subscription with the network device has been established, any commands and responses between the client device and the network device may be routed over pub/sub channels via the broker managers and their brokers using name-based routing, without routing based on IP address of the network device.

20 Claims, 14 Drawing Sheets



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H04L 45/302 (2022.01)
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CPC *H04L 45/02* (2013.01); *H04L 45/306*
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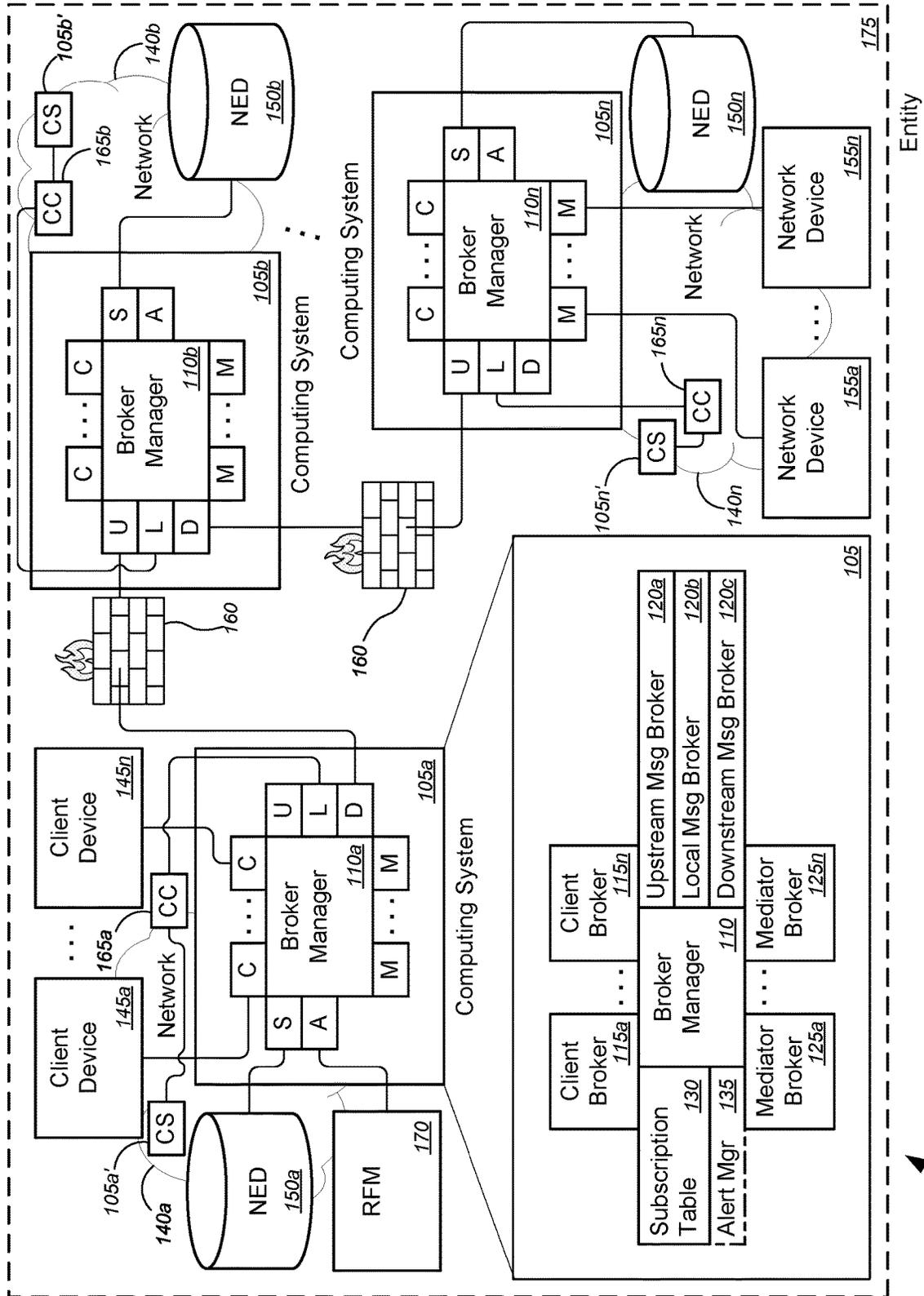
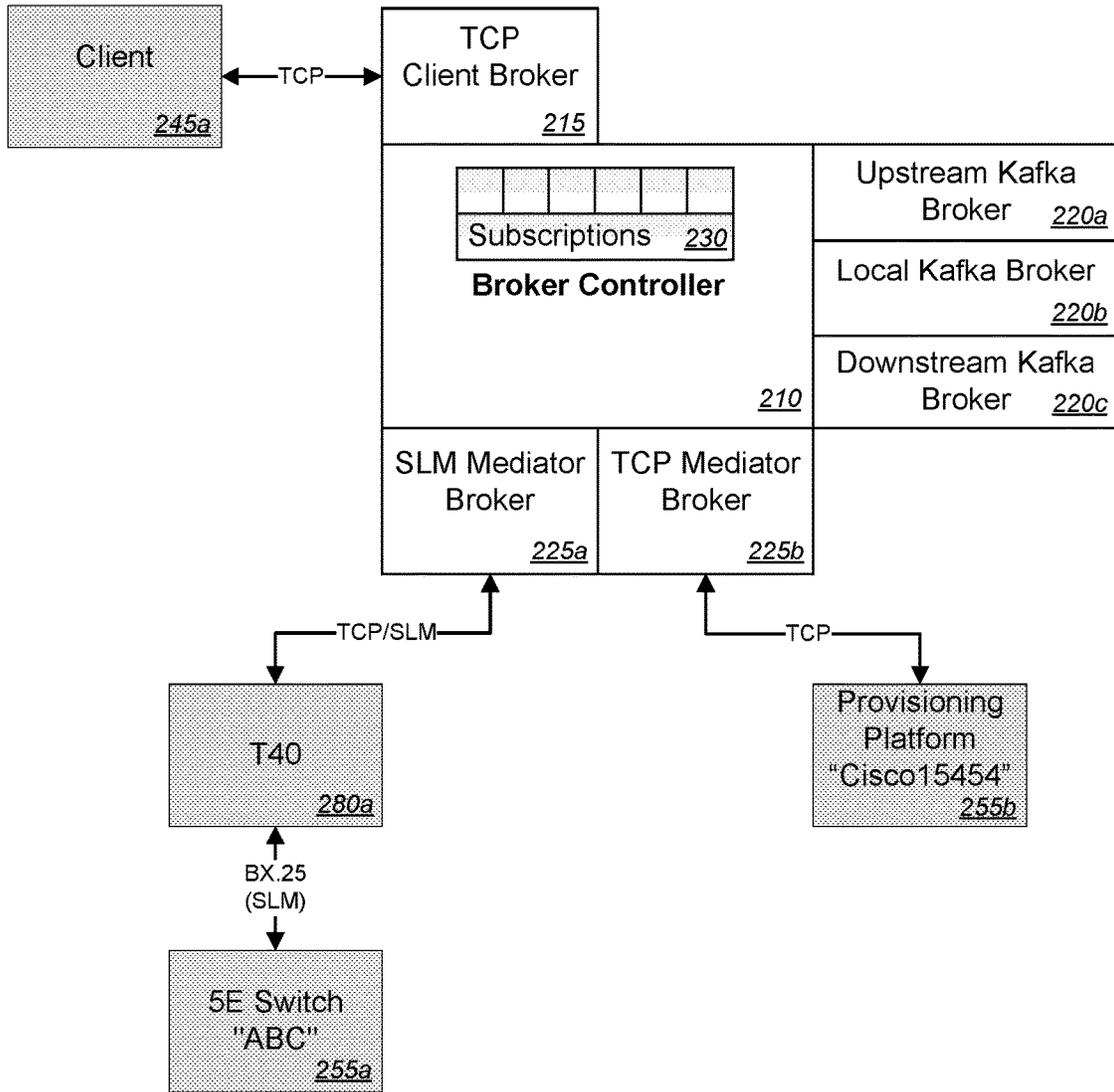


Fig. 1



200 ↗

Fig. 2A

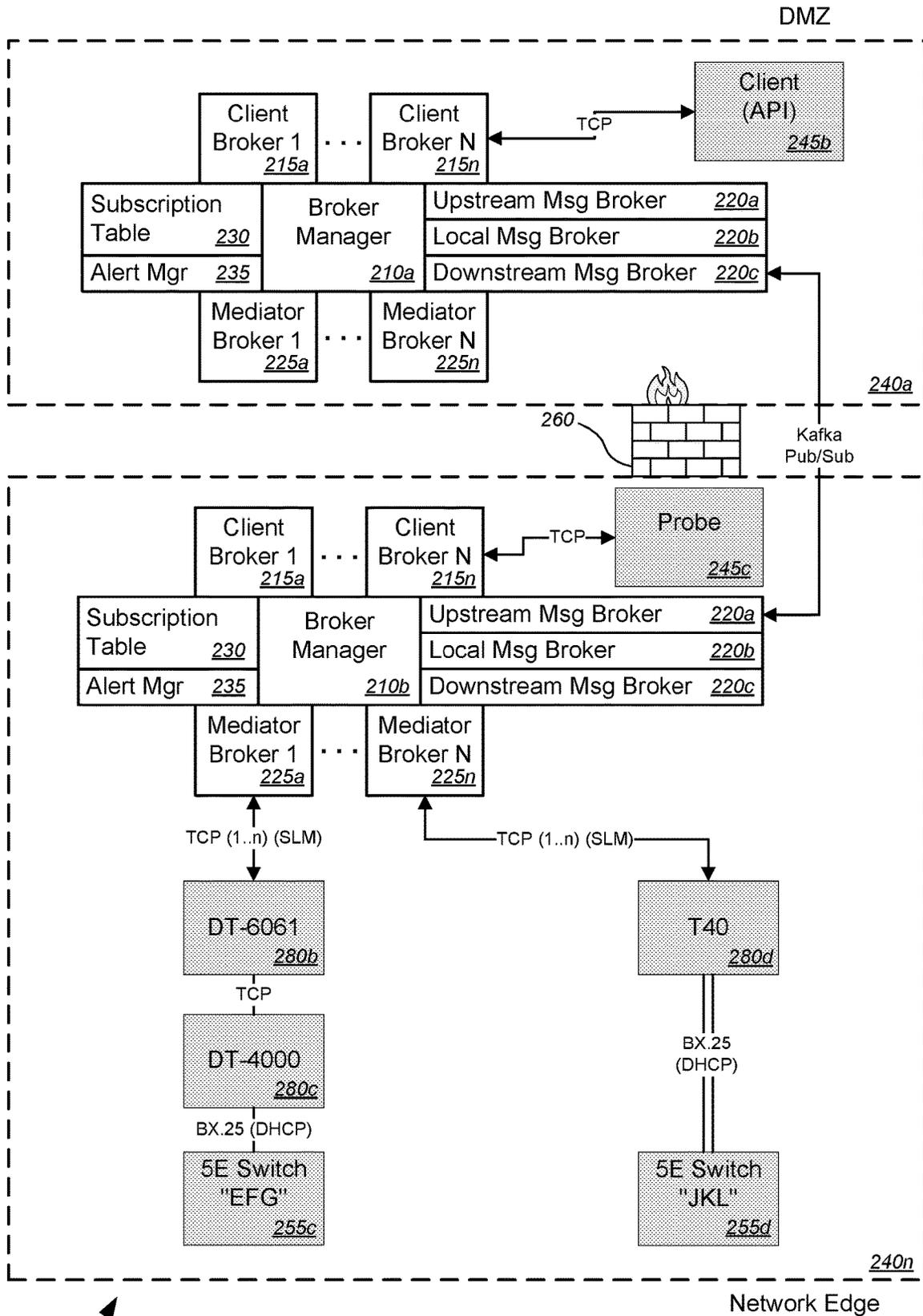
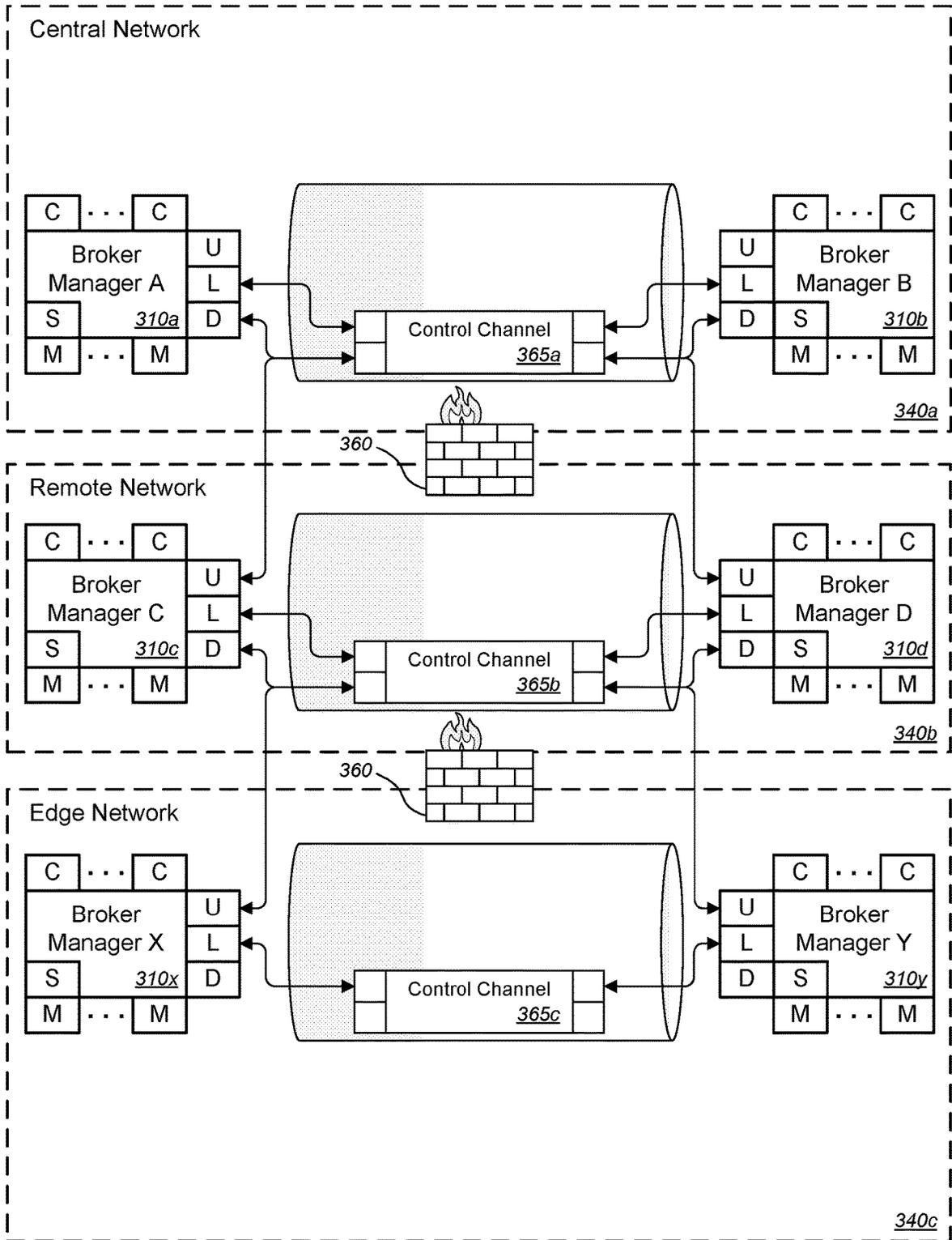
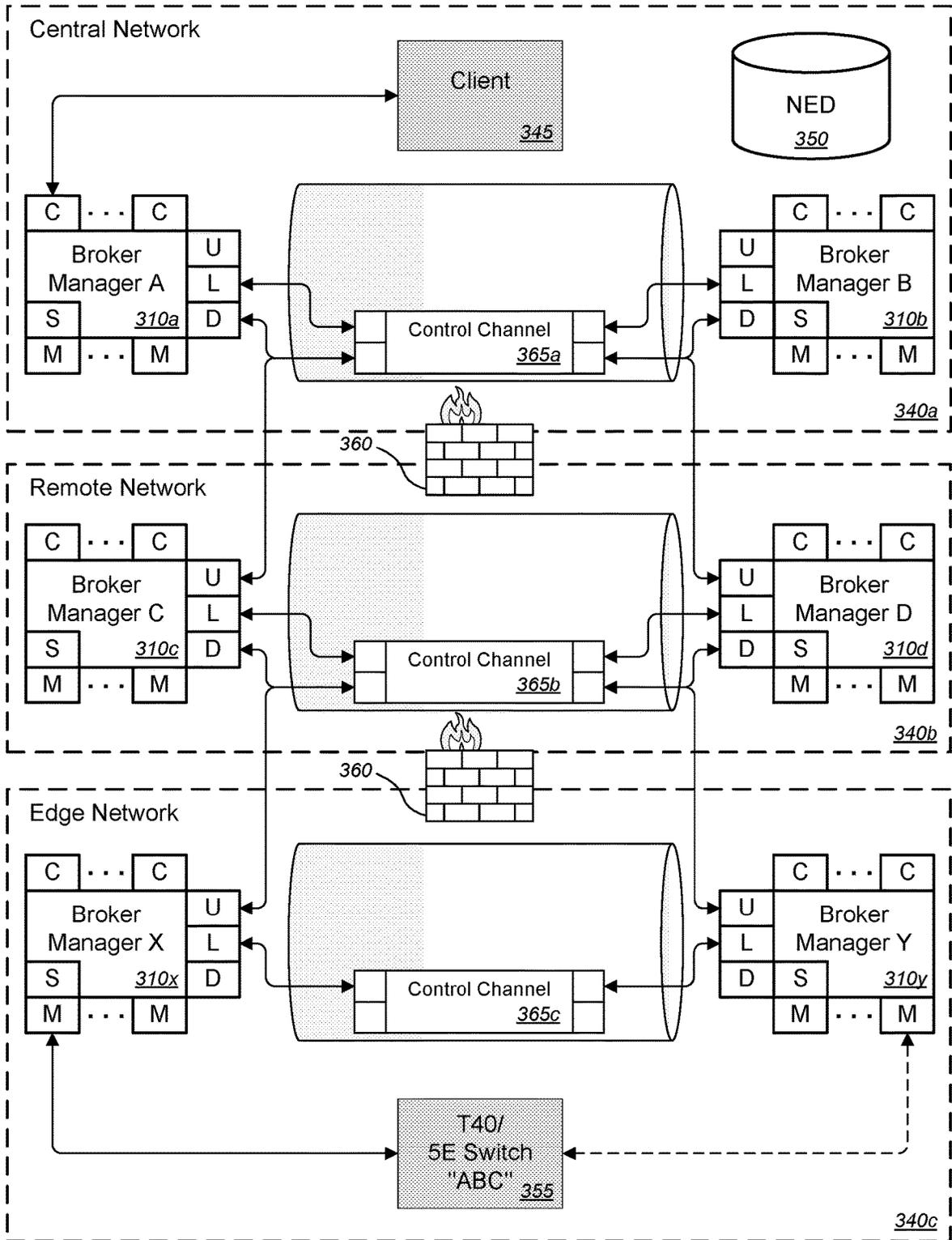


Fig. 2B



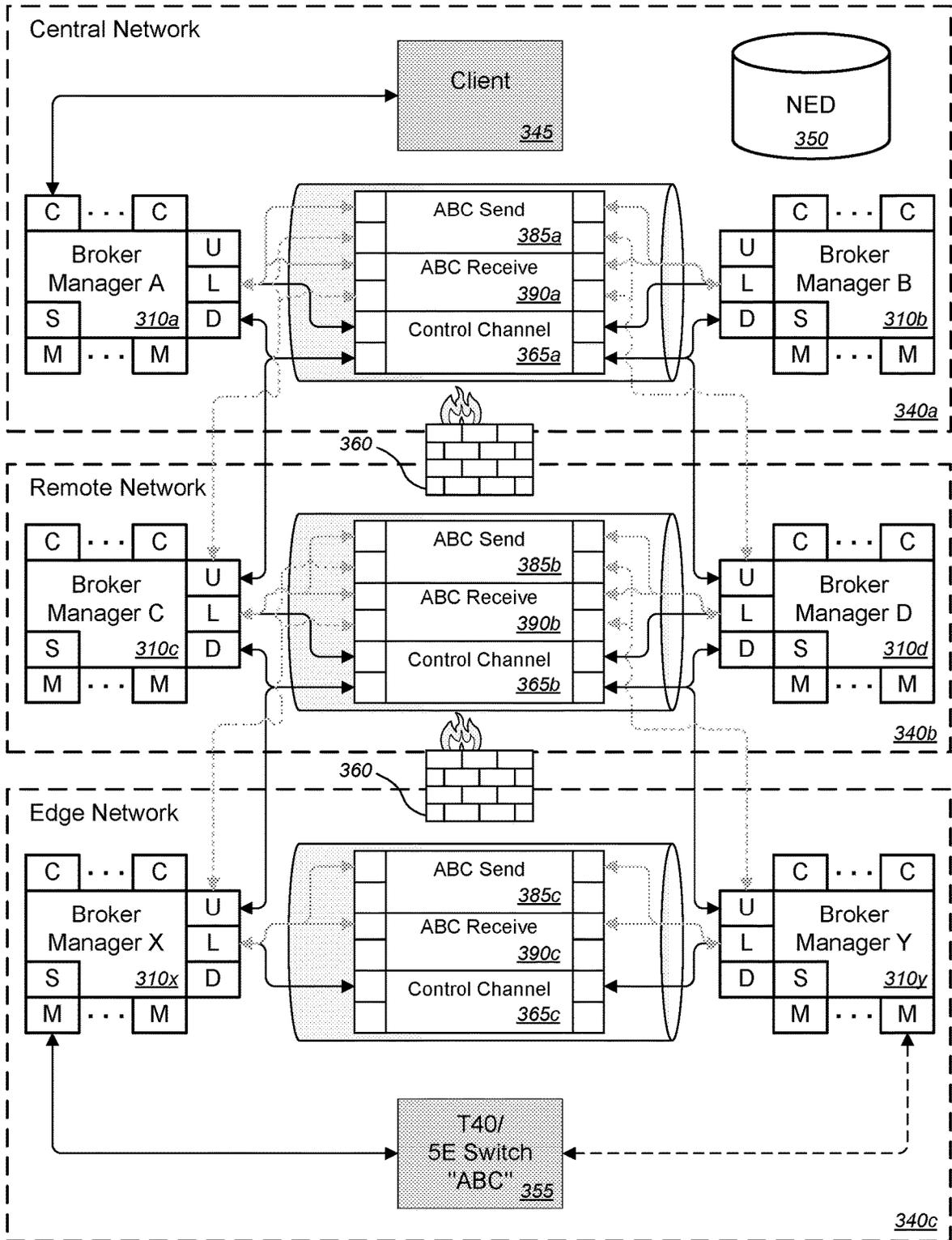
300 ↗

Fig. 3A



300

Fig. 3B



300

Fig. 3C

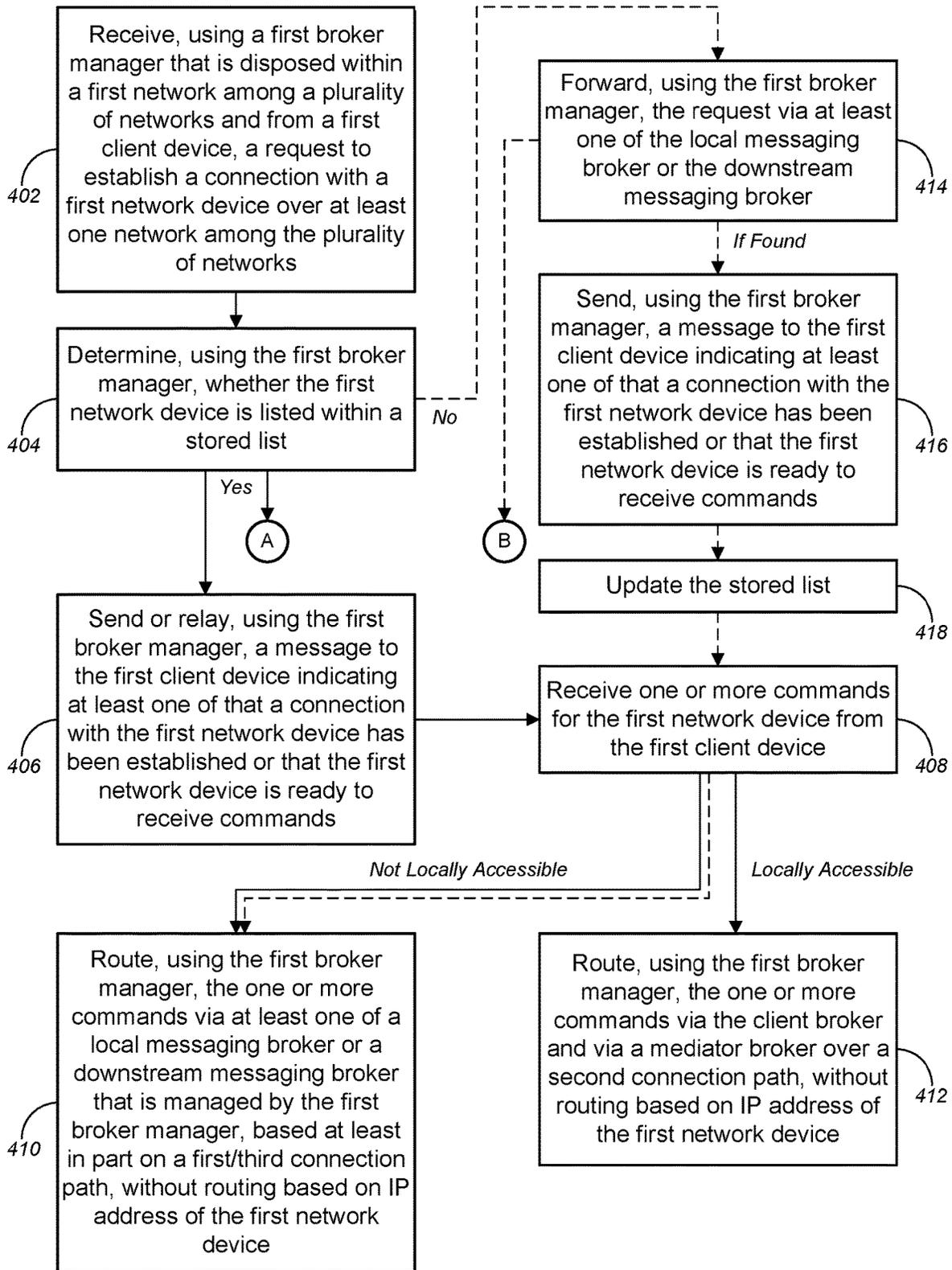


Fig. 4A

400

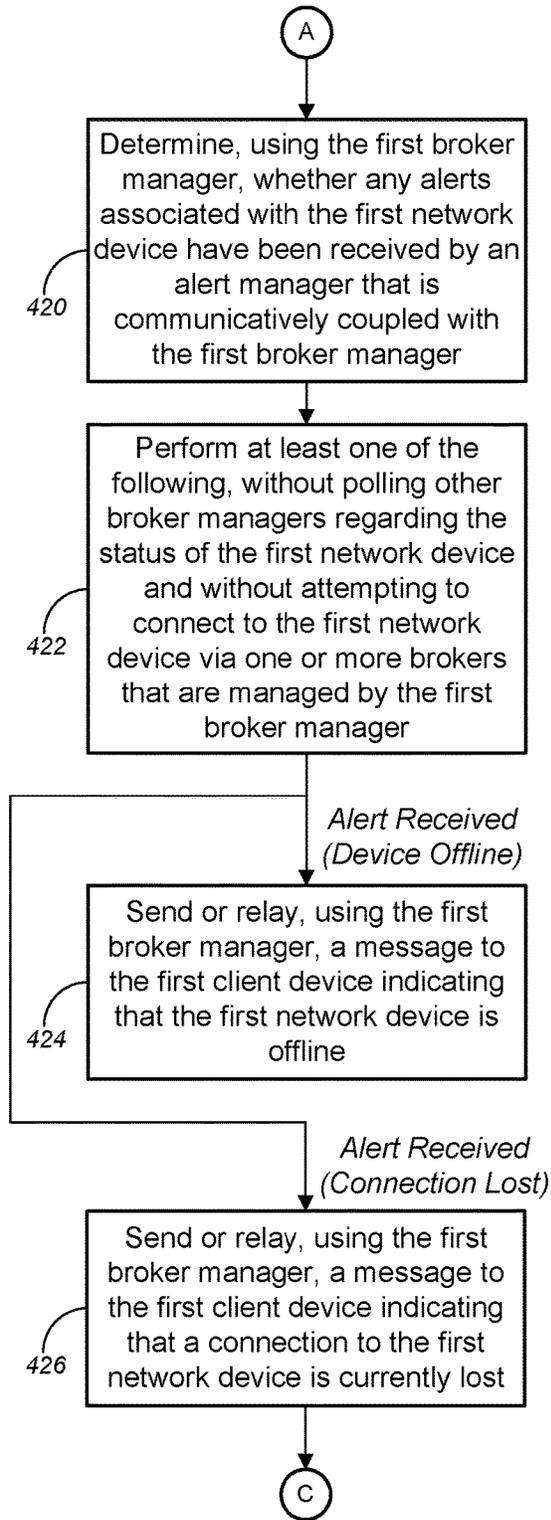


Fig. 4B

400

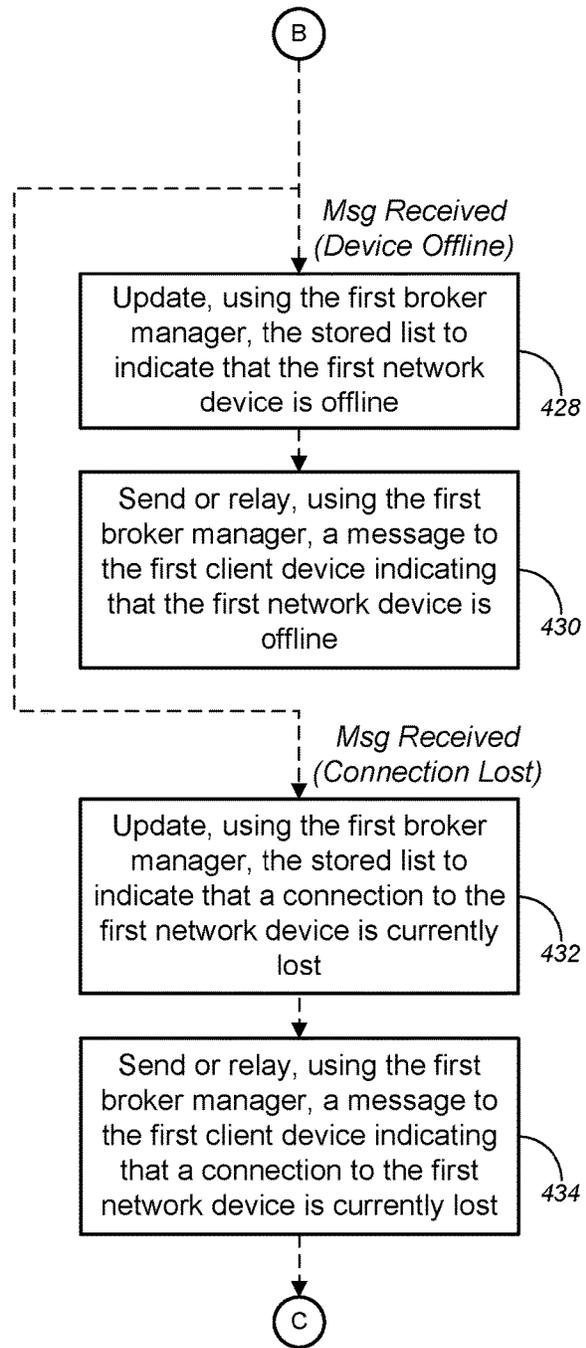


Fig. 4C

400

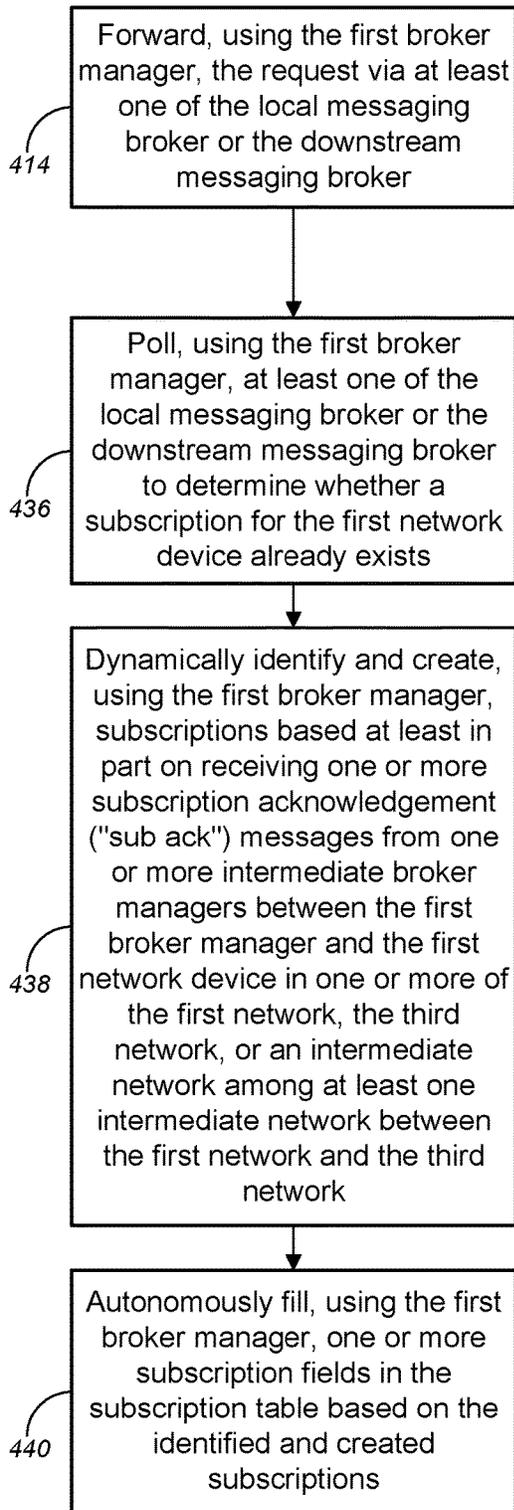


Fig. 4D

400

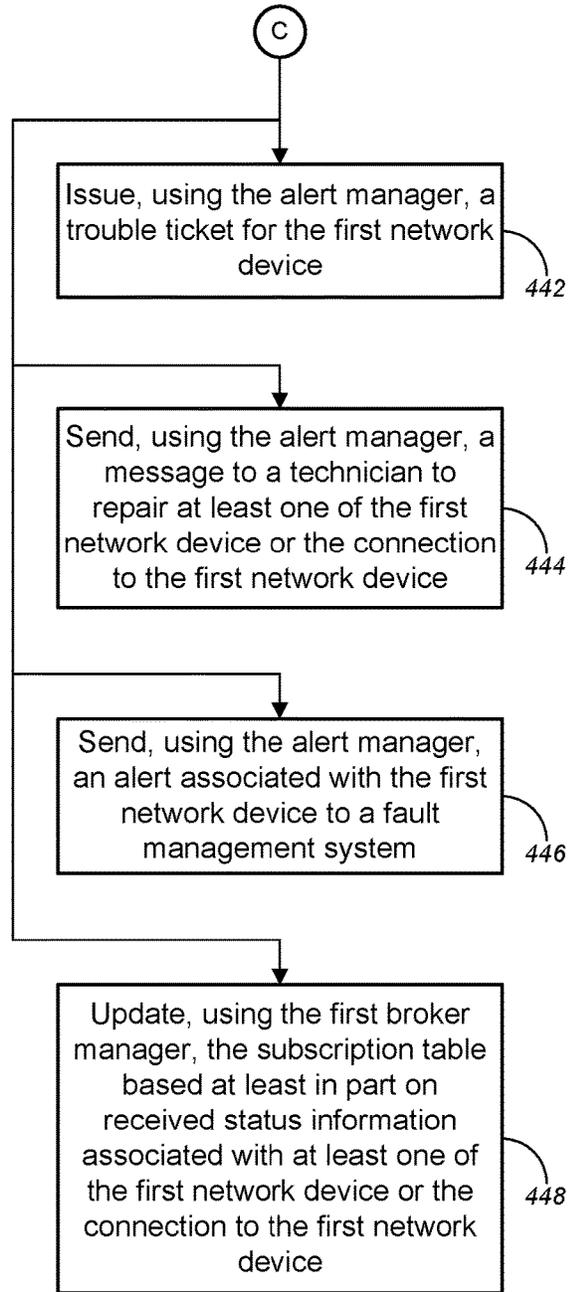


Fig. 4E

400

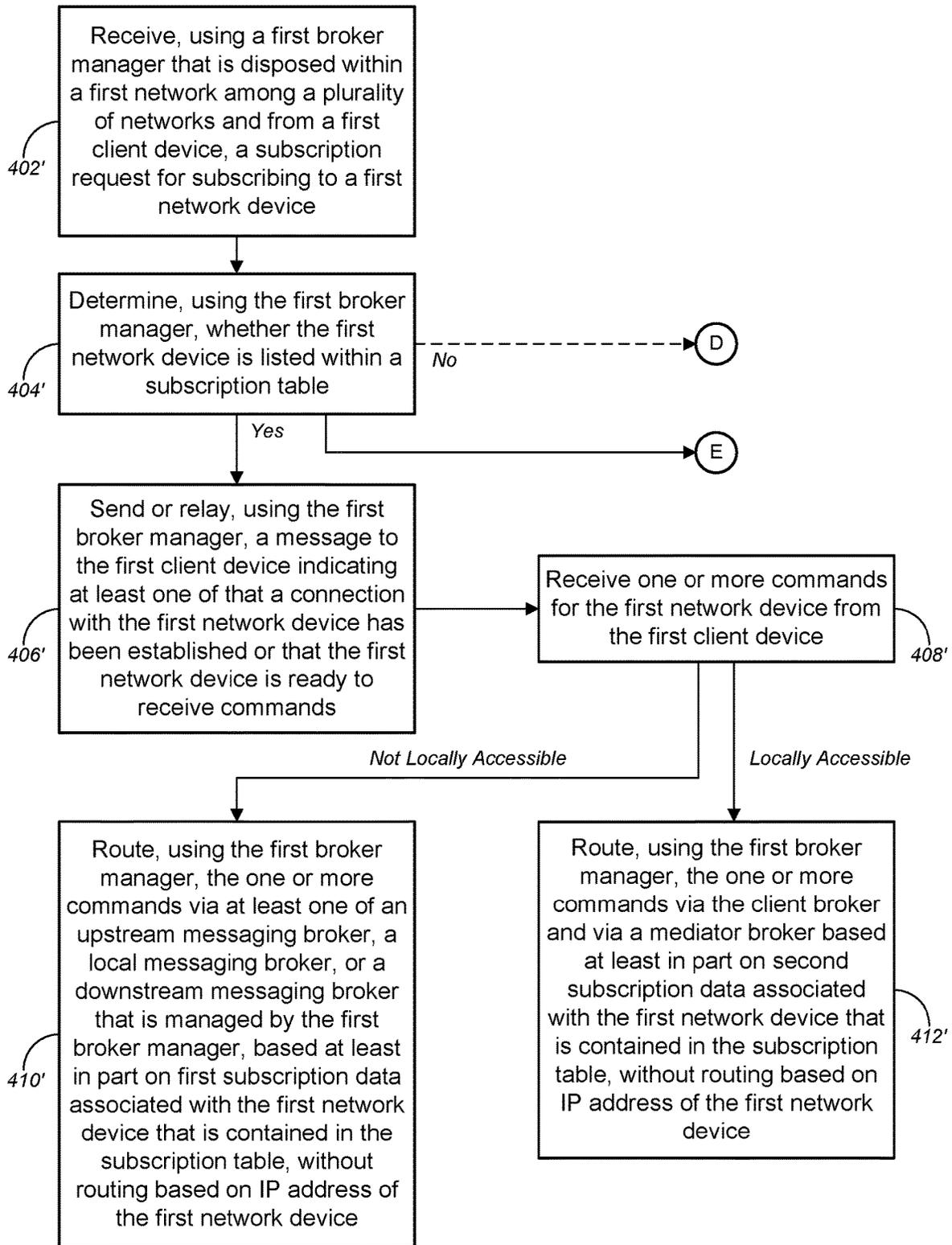


Fig. 4F

400

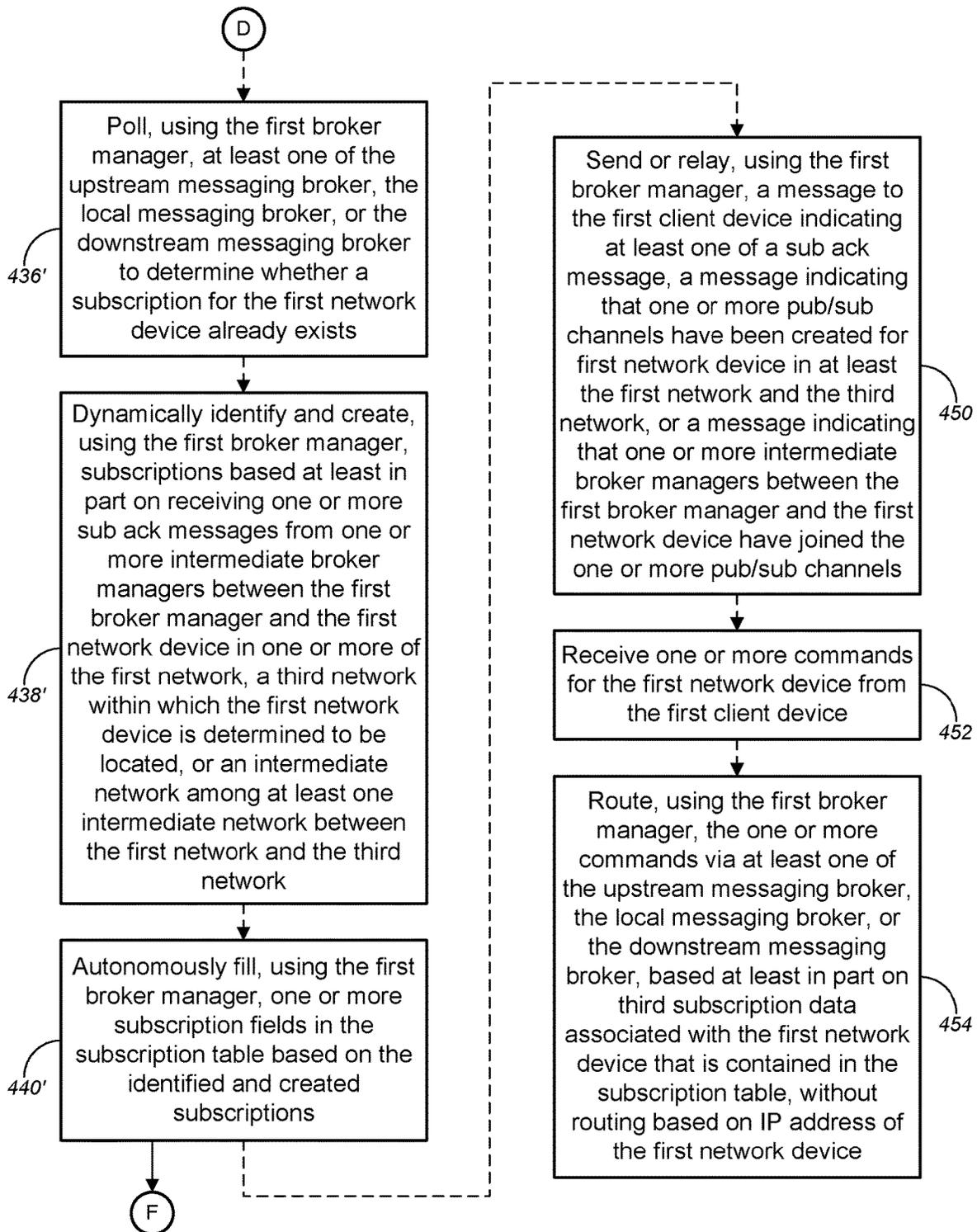


Fig. 4G

400

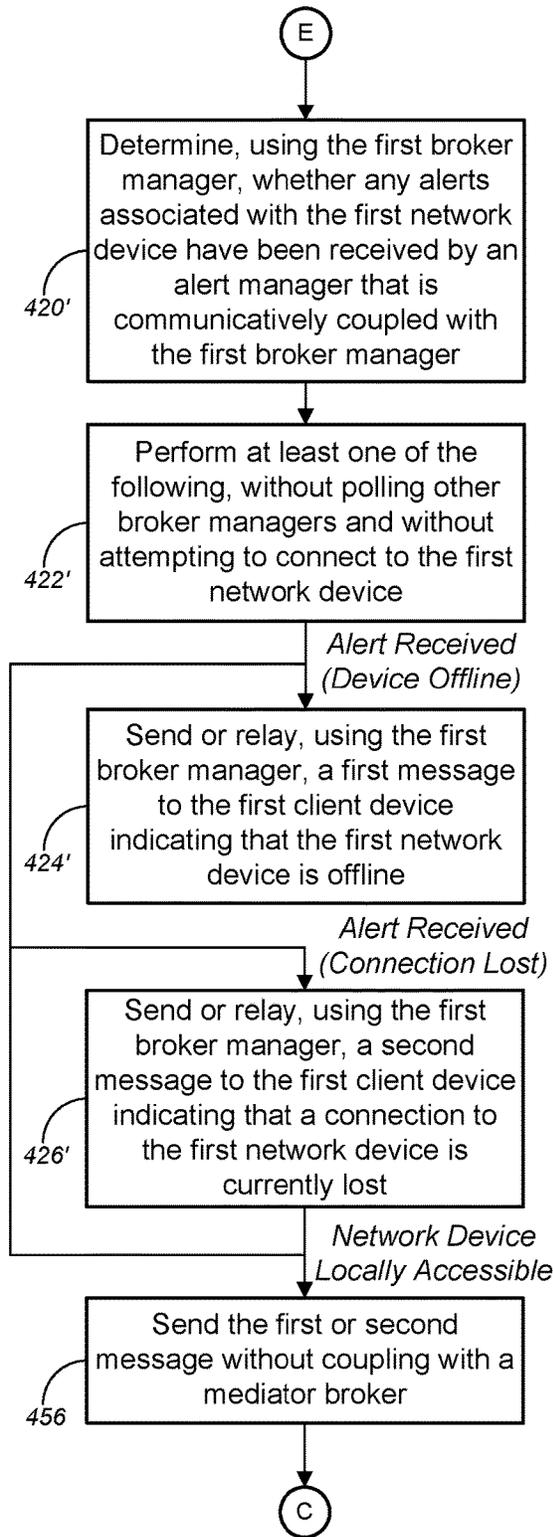


Fig. 4H

400

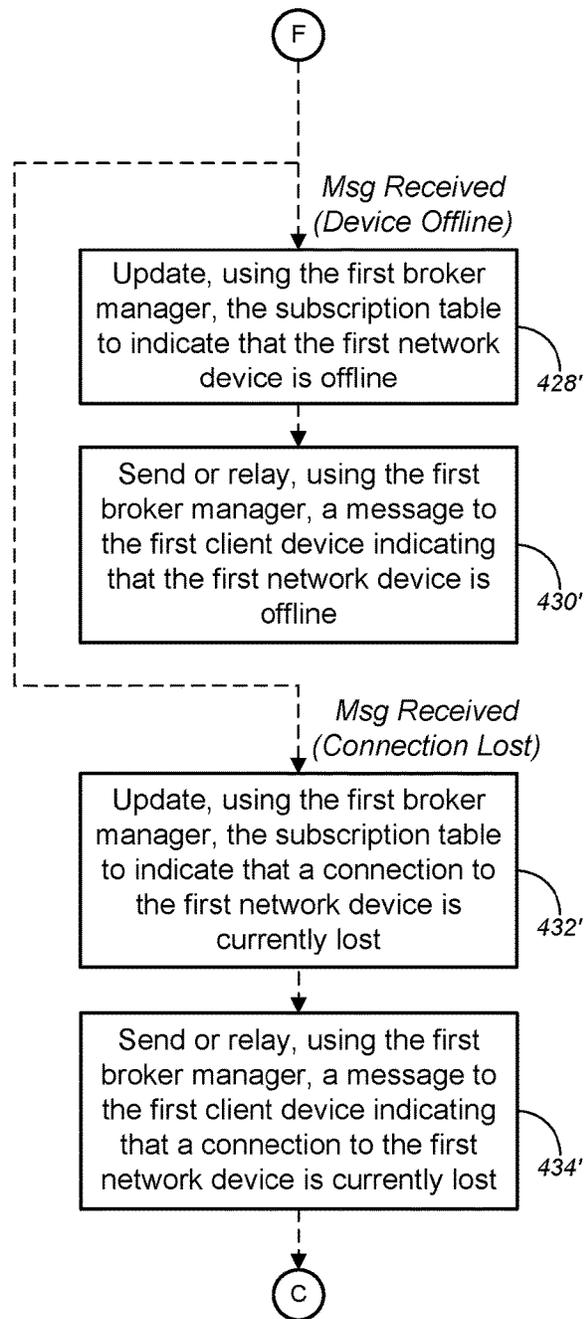


Fig. 4I

400

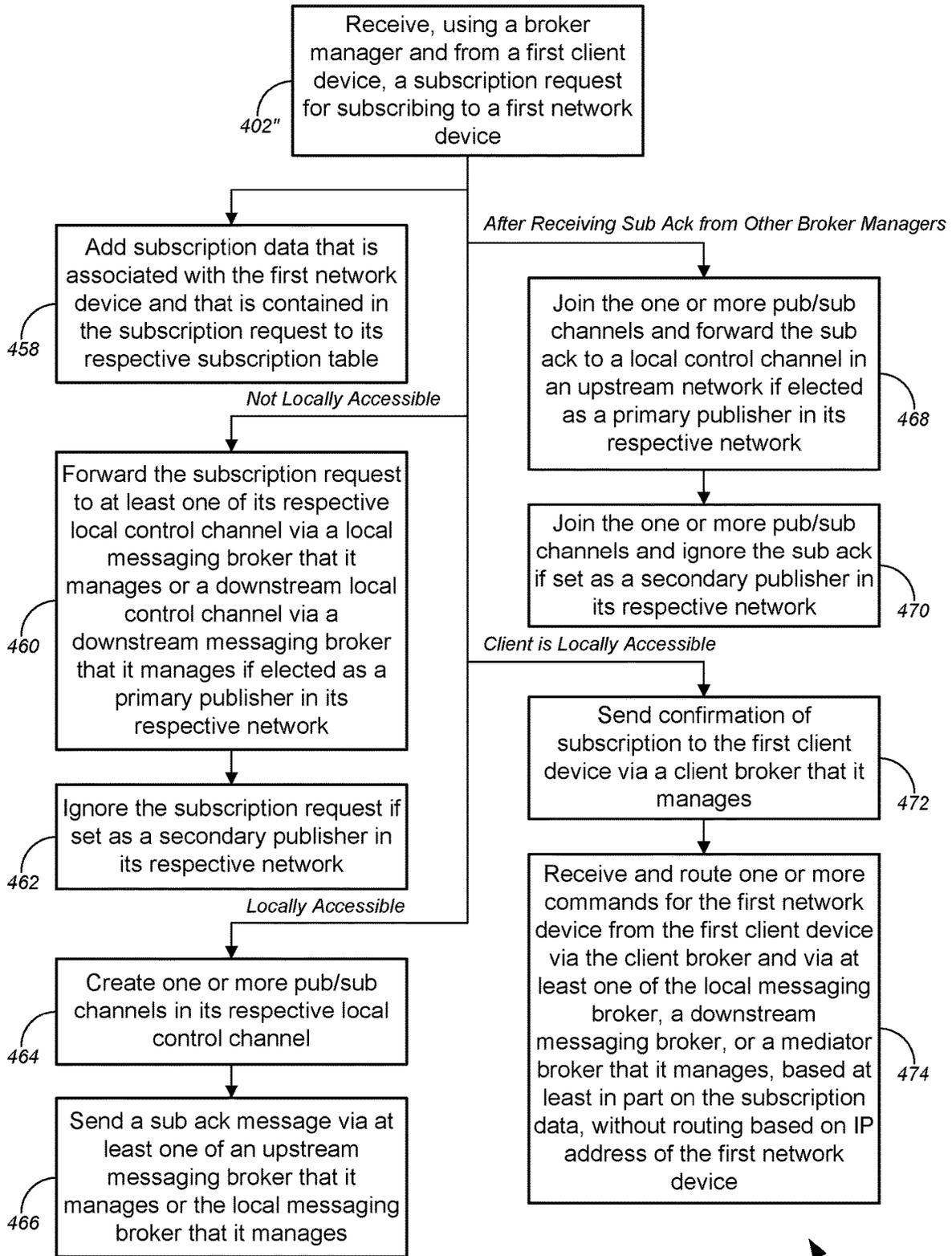
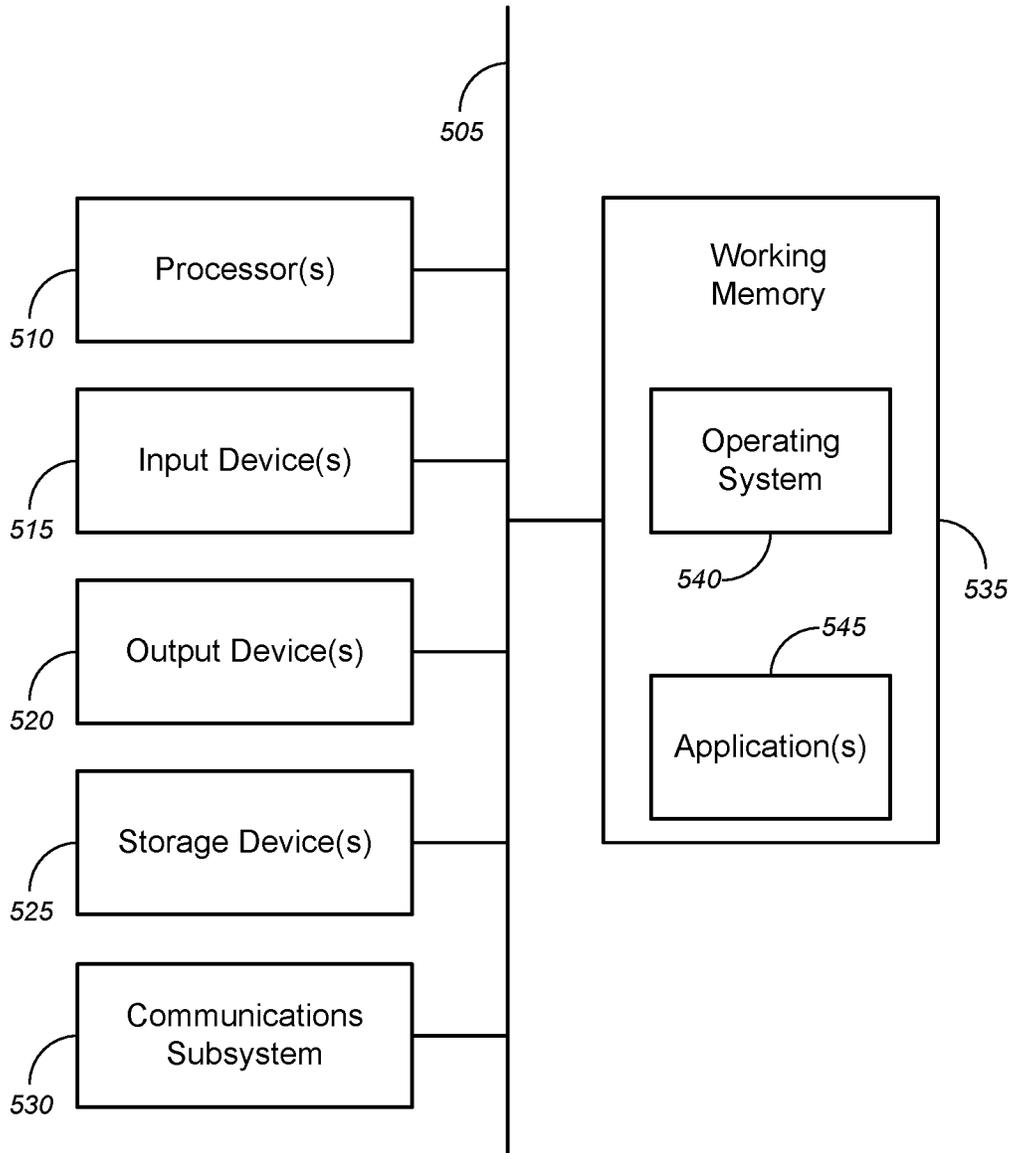


Fig. 4J

400



500

Fig. 5

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NAME-BASED ROUTING THROUGH NETWORKS

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FIELD

The present disclosure relates, in general, to methods, systems, and apparatuses for implementing network routing, and, more particularly, to methods, systems, and apparatuses for implementing name-based routing through networks.

BACKGROUND

Conventional network routing techniques are based on routing using Internet Protocol (“IP”) addresses. However, there is a very limited number of IP addresses, which means that different networks can use the same IP address for different devices, thus leading to IP conflicts.

Hence, there is a need for more robust and scalable solutions for implementing network routing, and, more particularly, to methods, systems, and apparatuses for implementing name-based routing through networks.

BRIEF DESCRIPTION OF THE DRAWINGS

A further understanding of the nature and advantages of particular embodiments may be realized by reference to the remaining portions of the specification and the drawings, in which like reference numerals are used to refer to similar components. In some instances, a sub-label is associated with a reference numeral to denote one of multiple similar components. When reference is made to a reference numeral without specification to an existing sub-label, it is intended to refer to all such multiple similar components. For denoting a plurality of components, the suffixes “a” through “n,” where n denotes any suitable integer number, and may be either the same or different from the suffix “n” for other components in the same or different figures. For example, for component #1 **105a-105n**, the integer value of n in **105n** may be the same or different from the integer value of n in **110n** for component #2 **110a-110n**, and so on.

FIG. 1 is a schematic diagram illustrating a system for implementing name-based routing through networks, in accordance with various embodiments.

FIGS. 2A and 2B are schematic diagrams illustrating various non-limiting examples of broker managers and their interconnections with other components during implementation of name-based routing through networks, in accordance with various embodiments.

FIGS. 3A-3C are schematic diagrams illustrating a non-limiting set of examples of a plurality of broker managers and their interconnections with other components across a plurality of networks during implementation of name-based routing through networks, in accordance with various embodiments.

FIGS. 4A-4J are flow diagrams illustrating a method for implementing name-based routing through networks, in accordance with various embodiments.

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FIG. 5 is a block diagram illustrating an exemplary computer or system hardware architecture, in accordance with various embodiments.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

Overview

Various embodiments provide tools and techniques for implementing network routing, and, more particularly, to methods, systems, and apparatuses for implementing name-based routing through networks.

In various embodiments, a primary broker manager in each of a plurality of networks may receive a subscription request for a network device from a client device, where each of the client device or the network device may be locally accessible in the same network or disposed in an upstream or downstream network. For a locally accessible client device, the primary broker manager uses its client broker to communicate with the client device. For a locally accessible network device, the primary broker manager uses its mediator broker (and, in some cases, one or more intermediate devices) to communicate with the network device. Primary broker manager otherwise uses its local messaging broker to communicate with its network’s local control channel, its upstream messaging broker to communicate with an upstream network’s local control channel, and its downstream messaging broker to communicate with a downstream network’s local control channel. Once subscription with the network device has been established, the client device is informed, and any commands for the network device from the client device and any responses from the network device to the client device may be routed over pub/sub channels created during the subscription process via the primary broker managers and their brokers using name-based routing (i.e., based on name of the network device, the network in which it is located, and connection information, etc.), without routing based on IP address of the network device. In some embodiments, alerts based on failures in connecting with the network device or connections to the network device (in some cases, with communicating with brokers, etc.) may be sent by the primary broker managers, and in some cases to fault management systems (e.g., real-time fault management system (“RFM”), or the like).

Name-based routing as described herein may enable one or more of the following features or characteristics (or otherwise provides the following functionalities): (a) provides virtual direct connection between a client and a device in a different network, which is separated from the client network by firewall, or the like; (b) can read the device from anywhere in the network(s); (c) acts like a “layer 4 extension cord”; (d) can pass through firewalls without having to open up ports and firewalls (thereby providing secure routing without requiring changes to the firewalls and ports for each routing instance); (e) can route by network and name rather than by IP address (which is limited in number, resulting in potential IP conflicts, or the like; compared with name-based routing that may utilize different naming conventions across networks and may likely use geographical identifiers in their names, or the like).

These and other aspects of the name-based routing through networks are described in greater detail with respect to the figures.

The following detailed description illustrates a few exemplary embodiments in further detail to enable one of skill in the art to practice such embodiments. The described

examples are provided for illustrative purposes and are not intended to limit the scope of the invention.

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the described embodiments. It will be apparent to one skilled in the art, however, that other embodiments of the present invention may be practiced without some of these specific details. In other instances, certain structures and devices are shown in block diagram form. Several embodiments are described herein, and while various features are ascribed to different embodiments, it should be appreciated that the features described with respect to one embodiment may be incorporated with other embodiments as well. By the same token, however, no single feature or features of any described embodiment should be considered essential to every embodiment of the invention, as other embodiments of the invention may omit such features.

Unless otherwise indicated, all numbers used herein to express quantities, dimensions, and so forth used should be understood as being modified in all instances by the term "about." In this application, the use of the singular includes the plural unless specifically stated otherwise, and use of the terms "and" and "or" means "and/or" unless otherwise indicated. Moreover, the use of the term "including," as well as other forms, such as "includes" and "included," should be considered non-exclusive. Also, terms such as "element" or "component" encompass both elements and components comprising one unit and elements and components that comprise more than one unit, unless specifically stated otherwise.

In an aspect, a method may comprise receiving, using a first broker manager that is disposed within a first network among a plurality of networks and from a first client device, a request to establish a connection with a first network device over at least one network among the plurality of networks; and determining, using the first broker manager, whether the first network device is listed within a stored list together with a connection path at least between the first broker manager and the first network device over the at least one network. The method may further comprise, based on a determination that the first network device is listed within the stored list together with a first connection path at least between the first broker manager and the first network device over the at least one network, and based on a determination that the first network device is not locally accessible by the first broker manager, performing the following: sending or relaying, using the first broker manager, a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands; and in response to receiving one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via at least one of a local messaging broker or a downstream messaging broker that is managed by the first broker manager, based at least in part on the first connection path, without routing based on Internet Protocol ("IP") address of the first network device, the first connection path comprising a name of the first network device and an identifier ("ID") of a second network within which the first network device is located.

In some embodiments, the first client device may be disposed within the first network. In some cases, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client

device, the request via a client broker. In some instances, the local messaging broker may communicatively couple with a control channel associated with the first network. In some cases, the downstream messaging broker may communicatively couple with a control channel associated with one of the second network or an intermediate network among one or more intermediate networks between the first network and the second network. In some instances, the ID of the second network comprises at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID of the second network, and/or the like. In some cases, each of the control channel associated with the first network, the control channel associated with the second network, and the control channel associated with the intermediate network may be clustered across multiple servers in its respective network.

According to some embodiments, the method may further comprise, based on a determination that the first network device is listed within the stored list together with a second connection path between the first broker manager and the first network device over the first network, and based on a determination that the first network device is locally accessible by the first broker manager, performing the following: sending or relaying, using the first broker manager, a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands; and, in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via the client broker and via a mediator broker over the second connection path, without routing based on IP address of the first network device, the second connection path comprising a name of the first network device and an ID of the first network, the mediator broker being managed by the first broker manager.

In some instances, the mediator broker may comprise at least one of one or more serial line management ("SLM") mediator brokers, one or more transmission control protocol ("TCP") mediator brokers, one or more hypertext transfer protocol ("HTTP") mediator brokers, one or more secure shell protocol ("SSH") mediator brokers, or one or more simple network management protocol ("SNMP") mediator brokers, and/or the like. In some cases, each of at least one SLM mediator broker among the one or more SLM mediator brokers may be configured to mediate multiple connections to multiple client devices regardless of whether the first network device to which it is communicatively coupled is only capable of single client-only connection. In some instances, one or more of the client broker, the local messaging broker, the downstream messaging broker, or the mediator broker that are managed by the first broker manager may be modular. In some cases, the client broker may be configured to be interchangeable with other client brokers, each messaging broker may be configured to be interchangeable with other messaging brokers, and the mediator broker may be configured to be interchangeable with other mediator brokers. In some instances, the first broker manager may be communicatively coupled to and may manage at least one of one or more client brokers, one or more messaging brokers, or one or more mediator brokers, and/or the like. In some cases, each client broker may comprise one of a single-port client broker that communicatively couples with a single client device or a multi-port client broker that communicatively couples with each of a plurality of client devices.

In some embodiments, the method may further comprise, based on a determination either that the first network device

is not listed within the stored list or that the first network device is listed within the stored list but without including a connection path between the first broker manager and the first network device, performing the following: forwarding, using the first broker manager, the request via at least one of the local messaging broker or the downstream messaging broker; after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating at least one of that a third connection path exists between the first broker manager and the first network device or that the first network device has been found, sending, using the first broker manager, a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands, or the like, wherein the stored list may be updated with the third connection path in association with the first network device by either the first broker manager or one of the at least one other broker manager; and, in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via the client broker and via the at least one of the local messaging broker or the downstream messaging broker over the third connection path, without routing based on IP address of the first network device, the third connection path comprising a name of the first network device and an ID of a third network within which the first network device is located.

In some instances, the stored list may comprise a subscription table associated with the first broker manager. In some cases, forwarding the request may comprise polling, using the first broker manager, at least one of the local messaging broker or the downstream messaging broker to determine whether a subscription for the first network device already exists. In some instances, the method may further comprise dynamically identifying and creating, using the first broker manager, subscriptions based at least in part on receiving one or more subscription acknowledgement (“sub ack”) messages from one or more intermediate broker managers between the first broker manager and the first network device in one or more of the first network, the third network, or an intermediate network among at least one intermediate network between the first network and the third network; and autonomously filling, using the first broker manager, one or more subscription fields in the subscription table based on the identified and created subscriptions.

In some cases, the first client device may be disposed within a fourth network among the plurality of networks. In some instances, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client device, the request via a second broker manager that is locally coupled with the first client device via its client broker and via an upstream messaging broker that is communicatively coupled with a control channel associated with one of the fourth network or an intermediate network among one or more intermediate networks between the first network and the fourth network, the upstream messaging broker being managed by the first broker manager. In some cases, sending or relaying the message to the first client device may comprise relaying, using the first broker manager, the message to the first client device via the upstream messaging broker and via the second broker manager. In some instances, routing the one or more commands may comprise routing, using the first broker manager, the one or more commands via at least one of the upstream messaging broker, the local messaging

broker, or the downstream messaging broker, based at least in part on the first connection path, without routing based on IP address of the first network device.

According to some embodiments, the first connection path may further comprise one or more communications channels between the first broker manager and the first network device, the one or more communications channels being joined by one or more intermediate broker managers between the first broker manager and the first network device. In some cases, the stored list may be maintained and updated within a network element database (“NED”). In some instances, the plurality of networks may be separated from each other by firewalls. Merely by way of example, in some cases, the first network device may comprise one of a network switch, an intermediary device, a multiservice provisioning platform, a gateway device, a network node, a router, a network security or firewall appliance, a telephone electronic switching system, an optical network switch and routing platform, a wavelength division multiplexing (“WDM”)—based optical transport network system, a network transmission system, a server, or a user device, and/or the like.

In some embodiments, the stored list may comprise a subscription table associated with the first broker manager. In some instances, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client device, a subscription request for subscribing to the first network device, the subscription request comprising subscription data associated with the first network device. In some cases, the message indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands may comprise at least one of a subscription acknowledgement (“sub ack”) message, a message indicating that one or more publication/subscription (“pub/sub”) channels have been created for the first network device in at least the first network and the second network, or a message indicating that one or more intermediate broker managers between the first broker manager and the first network device have joined the one or more pub/sub channels, and/or the like. In some instances, the method may further comprise adding, using the first broker manager, the subscription data to the subscription table. In some cases, routing the one or more commands may comprise routing the one or more commands based at least in part on subscription data contained in the subscription table.

In another aspect, a system may comprise a computing system that is disposed within a first network among a plurality of networks. The computing system may comprise a first broker manager, at least one first processor, and a first non-transitory computer readable medium communicatively coupled to the at least one first processor. The first non-transitory computer readable medium may have stored thereon computer software comprising a first set of instructions that, when executed by the at least one first processor, causes the first broker manager to: receive, from a first client device, a request to establish a connection with a first network device over at least one network among the plurality of networks; determine whether the first network device is listed within a stored list together with a connection path at least between the first broker manager and the first network device over the at least one network; and, based on a determination that the first network device is listed within the stored list together with a first connection path at least between the first broker manager and the first network device over the at least one network, and based on a

determination that the first network device is not locally accessible by the first broker manager, perform the following: sending or relaying a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands; and in response to receiving one or more commands for the first network device from the first client device, routing the one or more commands via at least one of a local messaging broker or a downstream messaging broker that is managed by the first broker manager, based at least in part on the first connection path, without routing based on Internet Protocol (“IP”) address of the first network device, the first connection path comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located.

In yet another aspect, a method may comprise receiving, using a first broker manager that is disposed within a first network among a plurality of networks and from the first client device, a subscription request for subscribing to the first network device; determining, using the first broker manager, whether the first network device is listed within a subscription table; based on a determination that the first network device is listed within the subscription table, and based on a determination that the first network device is not locally accessible by the first broker manager, performing the following: sending or relaying, using the first broker manager, a message to the first client device indicating at least one of a subscription acknowledgement (“sub ack”) message, a message indicating that one or more publication/subscription (“pub/sub”) channels have been created for the first network device in at least the first network and the second network, or a message indicating that one or more intermediate broker managers between the first broker manager and the first network device have joined the one or more pub/sub channels; and in response to receiving one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via at least one of an upstream messaging broker, a local messaging broker, or a downstream messaging broker that is managed by the first broker manager, based at least in part on first subscription data associated with the first network device that is contained in the subscription table, without routing based on Internet Protocol (“IP”) address of the first network device, the first subscription data comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located; and, based on a determination that the first network device is listed within the subscription table, and based on a determination that the first network device is locally accessible by the first broker manager, perform the following: sending or relaying, using the first broker manager, a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands; and in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via the client broker and via a mediator broker based at least in part on second subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device, the second subscription data comprising the name of the first network device and an ID of the first network, the mediator broker being managed by the first broker manager.

In some embodiments, receiving the subscription request may comprise receiving, using the first broker manager and from the first client device, the subscription request via a client broker. In some instances, the local messaging broker may communicatively couple with a control channel associated with the first network. In some cases, the downstream messaging broker may communicatively couple with a control channel associated with one of the second network or an intermediate network among one or more intermediate networks between the first network and the second network. In some instances, the upstream messaging broker may communicatively couple with a control channel associated with one of the fourth network or an intermediate network among one or more intermediate networks between the first network and the fourth network, in the case that the first network is disposed between the fourth network and the second network. In some cases, the ID of the second network may comprise at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID, and/or the like, of the second network.

According to some embodiments, the method may further comprise, based on a determination that the first network device is not listed within the subscription table, performing the following: polling, using the first broker manager, at least one of the upstream messaging broker, the local messaging broker, or the downstream messaging broker to determine whether a subscription for the first network device already exists; dynamically identifying and creating, using the first broker manager, subscriptions based at least in part on receiving one or more subscription acknowledgement (“sub ack”) messages from one or more intermediate broker managers between the first broker manager and the first network device in one or more of the first network, a third network within which the first network device is determined to be located, or an intermediate network among at least one intermediate network between the first network and the third network; autonomously filling, using the first broker manager, one or more subscription fields in the subscription table based on the identified and created subscriptions; sending or relaying, using the first broker manager, a message to the first client device indicating at least one of a sub ack message, a message indicating that one or more publication/subscription (“pub/sub”) channels have been created for the first network device in at least the first network and the third network, or a message indicating that one or more intermediate broker managers between the first broker manager and the first network device have joined the one or more pub/sub channels; and in response to receiving one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via at least one of the upstream messaging broker, the local messaging broker, or the downstream messaging broker, based at least in part on third subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device, the third subscription data comprising a name of the first network device and an ID of the third network within which the first network device is located.

In an aspect, a system may comprise a first plurality of broker managers disposed within a first network among a plurality of networks, a second plurality of broker managers disposed within a second network among the plurality of networks, and a first network device among a plurality of network devices. The first plurality of broker managers may comprise a first primary broker manager and at least one first secondary broker manager, the first primary broker being

elected by the first plurality of broker managers to be a primary publisher in the first network, the at least one first secondary broker manager each being configured to be a secondary publisher that is on hot standby in the first network, and the plurality of networks being separated from each other by firewalls. The second plurality of broker managers may comprise a second primary broker manager and at least one second secondary broker manager, the second primary broker manager being elected by the second plurality of broker managers to be a primary publisher in the second network, and the at least one second secondary broker manager each being configured to be a secondary publisher that is on hot standby in the second network. The first network device may be disposed in the second network.

In some cases, in response to receiving a subscription request from a first client device for subscribing to the first network device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers may be configured to perform at least one of: adding subscription data that is associated with the first network device and that is contained in the subscription request to its respective subscription table, the subscription data comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located; based on a determination that the first network device is not locally accessible, forwarding the subscription request to at least one of its respective local control channel via a local messaging broker that it manages or a downstream local control channel via a downstream messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the subscription request if set as a secondary publisher in its respective network; or based on a determination that the first network device is locally accessible, creating one or more publication/subscription (“pub/sub”) channels in its respective local control channel, and sending a subscription acknowledgement (“sub ack”) message via at least one of an upstream messaging broker that it manages or the local messaging broker that it manages; and/or the like.

According to some embodiments, in response to receiving the subscription request from a first client device for subscribing to the first network device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers may be further configured to perform at least one of: in response to receiving the sub ack message from another broker manager, joining the one or more pub/sub channels, forwarding the sub ack message to a local control channel in an upstream network if elected as a primary publisher in its respective network, and ignoring the sub ack message if set as a secondary publisher in its respective network; or if the first client device is locally accessible to it, sending confirmation of subscription to the first client device via a client broker that it manages, and receiving and routing one or more commands for the first network device from the first client device via the client broker and via at least one of the local messaging broker, a downstream messaging broker, or a mediator broker that it manages, based at least in part on the subscription data, without routing based on Internet Protocol (“IP”) address of the first network device; and/or the like.

In some embodiments, each broker manager receiving the subscription request may comprise each broker manager receiving the subscription request via at least one of a client broker, the upstream messaging broker, the local messaging broker, or the downstream messaging broker, and/or the like, that it manages. In some cases, the local messaging broker for each broker manager may communicatively couple with

a control channel associated with its respective network. In some instances, the downstream messaging broker for each broker manager may communicatively couple with a control channel associated with one of its respective network or a downstream intermediate network among one or more downstream intermediate networks between its respective network and the second network. In some cases, the upstream messaging broker for each broker manager may communicatively couple with a control channel associated with one of a fourth network within which the client device is disposed if not disposed in the first network or an upstream intermediate network among one or more upstream intermediate networks between the first network and the fourth network, in the case that the first network is disposed between the fourth network and the second network. In some instances, the ID of the second network may comprise at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID, and/or the like, of the second network.

Merely by way of example, in some cases, the mediator broker may comprise at least one of one or more serial line management (“SLM”) mediator brokers, one or more transmission control protocol (“TCP”) mediator brokers, one or more hypertext transfer protocol (“HTTP”) mediator brokers, one or more secure shell protocol (“SSH”) mediator brokers, or one or more simple network management protocol (“SNMP”) mediator brokers, and/or the like. In some instances, each of at least one SLM mediator broker among the one or more SLM mediator brokers may be configured to mediate multiple connections to multiple client devices regardless of whether the first network device to which it is communicatively coupled is only capable of single client-only connection.

In some cases, one or more of the client broker, the upstream messaging broker, the local messaging broker, the downstream messaging broker, or the mediator broker may be modular. In some instances, the client broker may be configured to be interchangeable with other client brokers, each messaging broker may be configured to be interchangeable with other messaging brokers, and the mediator broker may be configured to be interchangeable with other mediator brokers. In some cases, each broker manager may be communicatively coupled to and may manage at least one of one or more client brokers, one or more messaging brokers, or one or more mediator brokers, and/or the like. In some instances, each client broker may comprise one of a single-port client broker that communicatively couples with a single client device or a multi-port client broker that communicatively couples with each of a plurality of client devices.

In some instances, each subscription table associated a corresponding broker manager among the first plurality of broker managers and among the second plurality of broker managers may be maintained and updated within a network element database (“NED”). Merely by way of example, in some cases, the first network device may comprise one of a network switch, an intermediary device, a multiservice provisioning platform, a gateway device, a network node, a router, a network security or firewall appliance, a telephone electronic switching system, an optical network switch and routing platform, a wavelength division multiplexing (“WDM”)—based optical transport network system, a network transmission system, a server, or a user device, and/or the like.

According to some embodiments, the system may further comprise a first local control channel disposed in the first network; and a second local control channel disposed in the

second network. In some instances, each of the first local control channel and the second local control channel may be clustered across multiple servers in its respective network. In some cases, the second primary broker manager may communicatively couple with the first network device via its mediator broker. In some instances, the first client device may be disposed within the first network. In some cases, the first primary broker manager may communicatively couple with the first client device via its client broker. In some instances, the first primary broker manager may communicatively couple with the first local control channel via its local messaging broker. In some instances, the first primary broker manager may communicatively couple with the second local control channel via its downstream messaging broker.

In some embodiments, the system may further comprise a third plurality of broker managers disposed within a third network among the plurality of networks, and a third local control channel disposed in the third network. The third plurality of broker managers may comprise a third primary broker manager and at least one third secondary broker manager, the third primary broker manager being elected by the third plurality of broker managers to be a primary publisher in the third network, the at least one third secondary broker manager each being configured to be a secondary publisher that is on hot standby in the third network, and the third network being a downstream intermediate network among one or more downstream intermediate networks between the first network and the second network. In some cases, the first primary broker manager may communicatively couple with the second local control channel, via the third local control channel and via its downstream messaging broker.

According to some embodiments, the system may further comprise a fourth plurality of broker managers disposed within a fourth network among the plurality of networks, and a fourth local control channel disposed in the fourth network. The fourth plurality of broker managers may comprise a fourth primary broker manager and at least one fourth secondary broker manager, the fourth primary broker manager being elected by the fourth plurality of broker managers to be a primary publisher in the fourth network, and the at least one fourth secondary broker manager each being configured to be a secondary publisher that is on hot standby in the fourth network. In some instances, the first client device may be disposed within the fourth network. In some cases, the first primary broker manager may communicatively couple with the first client device via the fourth local control channel, via the fourth primary broker manager, and via its upstream messaging broker. In some instances, the first primary broker manager may communicatively couple with the first local control channel via its local messaging broker. In some cases, the first primary broker manager may communicatively couple with the second local control channel via its downstream messaging broker.

In some embodiments, the system may further comprise a fifth plurality of broker managers disposed within a fifth network among the plurality of networks, and a fifth local control channel disposed in the fifth network. The fifth plurality of broker managers may comprise a fifth primary broker manager and at least one fifth secondary broker manager, the fifth primary broker manager being elected by the fifth plurality of broker managers to be a primary publisher in the fifth network, the at least one fifth secondary broker manager each being configured to be a secondary publisher that is on hot standby in the fifth network, and the

fifth network being an upstream intermediate network among one or more upstream intermediate networks between the first network and the fourth network. In some instances, the first primary broker manager may communicatively couple with the fourth local control channel via the fifth local control channel and via its upstream messaging broker.

According to some embodiments, the system may further comprise, in response to receiving one or more commands for the first network device from the first client device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers may be further configured to perform at least one of: based on a determination that the first network device is not locally accessible, routing the one or more commands to at least one of its respective local control channel via the local messaging broker that it manages or the downstream local control channel via the downstream messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the one or more commands if set as a secondary publisher in its respective network; or based on a determination that the first network device is locally accessible, routing the one or more commands to the first network device via its mediator broker. In some instances, routing the one or more commands may be based at least in part on subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device.

In some embodiments, in response to receiving a reply from the first network device for the first client device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers may be further configured to perform at least one of: based on a determination that the first client device is not locally accessible, routing the reply to at least one of its respective local control channel via the local messaging broker that it manages or an upstream local control channel via the upstream messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the reply if set as a secondary publisher in its respective network; or based on a determination that the first client device is locally accessible, routing the reply to the first client device via its client broker; and/or the like.

According to some embodiments, after it initializes or powers on, each broker manager among the first plurality of broker managers and among the second plurality of broker managers may be further configured to perform at least one of: initializing one or more mediator brokers it is managing; initializing one or more client brokers it is managing; connecting to at least one of its respective local control channel via the local messaging broker that it manages, a downstream local control channel in a downstream network via the downstream messaging broker that it manages, or an upstream local control channel in an upstream network via the upstream messaging broker that it manages, and/or the like; sending a hello message over at least one of its respective local control channel, the downstream local control channel in the downstream network, or the upstream local control channel in the upstream network; or, in response to receiving a hello acknowledgement (“hello ack”) message from each of one or more broker managers among the first plurality of broker managers and among the second plurality of broker managers, marking presence of each of the one or more broker managers; and/or the like.

Merely by way of example, in some cases, each broker manager among the first plurality of broker managers and among the second plurality of broker managers may com-

prise at least one of a virtual broker manager, a software-based (“SW”) broker manager, or a broker manager software application (“app”), and/or the like.

In another aspect, a method may comprise, in response to receiving a subscription request from a first client device for subscribing to a first network device, a broker manager performing at least one of the following: adding subscription data that is associated with the first network device and that is contained in the subscription request to its respective subscription table, the subscription data comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located; based on a determination that the first network device is not locally accessible, forwarding the subscription request to at least one of its respective local control channel via a local messaging broker that it manages or a downstream local control channel via a downstream messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the subscription request if set as a secondary publisher in its respective network, wherein the primary publisher in its respective network is elected by other broker managers in its respective network to perform publication/subscription (“pub/sub”) functions used in name-based routing, wherein the secondary publisher is on hot standby in its respective network to take over pub/sub functions during failover events involving the primary publisher; or based on a determination that the first network device is locally accessible, creating one or more pub/sub channels in its respective local control channel, and sending a subscription acknowledgement (“sub ack”) message via at least one of an upstream messaging broker that it manages or the local messaging broker that it manages, or the like. In some instances, the broker manager may be among a first plurality of broker managers that is disposed within a first network among a plurality of networks and among a second plurality of broker managers that is disposed within a second network among the plurality of networks. In some cases, the plurality of networks may be separated from each other by firewalls.

In some instances, in response to receiving the subscription request from the first client device for subscribing to the first network device, the broker manager may further perform at least one of the following: in response to receiving the sub ack message from another broker manager, joining the one or more pub/sub channels, forwarding the sub ack message to a local control channel in an upstream network if elected as a primary publisher in its respective network, and ignoring the sub ack message if set as a secondary publisher in its respective network; or if the first client device is locally accessible to it, sending confirmation of subscription to the first client device via a client broker that it manages, and receiving and routing one or more commands for the first network device from the first client device via the client broker and via at least one of the local messaging broker, a downstream messaging broker, or a mediator broker that it manages, based at least in part on the subscription data, without routing based on Internet Protocol (“IP”) address of the first network device.

In some cases, receiving the subscription request may comprise the broker manager receiving the subscription request via at least one of a client broker, the upstream messaging broker, the local messaging broker, or the downstream messaging broker, and/or the like, that it manages. In some instances, the local messaging broker for each broker manager may communicatively couple with a control channel associated with its respective network. In some cases, the downstream messaging broker for each broker manager may

communicatively couple with a control channel associated with one of its respective network or a downstream intermediate network among one or more downstream intermediate networks between its respective network and the second network. In some instances, the upstream messaging broker for each broker manager may communicatively couple with a control channel associated with one of a fourth network within which the client device is disposed if not disposed in the first network or an upstream intermediate network among one or more upstream intermediate networks between the first network and the fourth network, in the case that the first network is disposed between the fourth network and the second network. In some cases, the ID of the second network may comprise at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID, and/or the like, of the second network. Merely by way of example, in some cases, the mediator broker may comprise at least one of one or more serial line management (“SLM”) mediator brokers, one or more transmission control protocol (“TCP”) mediator brokers, one or more hypertext transfer protocol (“HTTP”) mediator brokers, one or more secure shell protocol (“SSH”) mediator brokers, or one or more simple network management protocol (“SNMP”) mediator brokers, and/or the like.

In yet another aspect, a system may comprise a first plurality of broker managers disposed within a first network among a plurality of networks, a second plurality of broker managers disposed within a second network among the plurality of networks, a first network device among a plurality of network devices that is disposed in the second network, and a computing system that is disposed within one of the plurality of networks. In some cases, the first plurality of broker managers may comprise a first primary broker manager and at least one first secondary broker manager, the first primary broker being elected by the first plurality of broker managers to be a primary publisher in the first network, the at least one first secondary broker manager each being configured to be a secondary publisher that is on hot standby in the first network, and the plurality of networks being separated from each other by firewalls. In some instances, the second plurality of broker managers may comprise a second primary broker manager and at least one second secondary broker manager, the second primary broker manager being elected by the second plurality of broker managers to be a primary publisher in the second network, and the at least one second secondary broker manager each being configured to be a secondary publisher that is on hot standby in the second network. In some cases, the computing system may comprise: a broker manager among the first plurality of broker managers and among the second plurality of broker managers; at least one first processor; and a first non-transitory computer readable medium communicatively coupled to the at least one first processor. The first non-transitory computer readable medium may have stored thereon computer software comprising a first set of instructions that, when executed by the at least one first processor, causes the broker manager to: in response to receiving a subscription request from a first client device for subscribing to the first network device, add subscription data that is associated with the first network device and that is contained in the subscription request to its respective subscription table, the subscription data comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located; based on a determination that the first network device is not locally accessible, forward the subscription request to at least one of its respective local control channel via a local messaging

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broker that it manages or a downstream local control channel via a downstream messaging broker that it manages if elected as a primary publisher in its respective network, and ignore the subscription request if set as a secondary publisher in its respective network; or based on a determination that the first network device is locally accessible, create one or more publication/subscription (“pub/sub”) channels in its respective local control channel, and send a subscription acknowledgement (“sub ack”) message via at least one of an upstream messaging broker that it manages or the local messaging broker that it manages.

In an aspect, a method may comprise receiving, using a first broker manager that is disposed within a first network among a plurality of networks and from a first client device, a request to establish a connection with a first network device over at least one network among the plurality of networks. The method may further comprise, based on a determination that the first network device is listed within a stored list, determining, using the first broker manager, whether any alerts associated with the first network device have been received by an alert manager that is communicatively coupled with the first broker manager, and performing at least one of the following, without polling other broker managers regarding the status of the first network device and without attempting to connect to the first network device via one or more brokers that are managed by the first broker manager: based on a determination that an alert has been received that indicates that the first network device is offline, sending or relaying, using the first broker manager, a message to the first client device indicating that the first network device is offline; or based on a determination that an alert has been received that indicates that a connection to the first network device is currently lost, sending or relaying, using the first broker manager, a message to the first client device indicating that a connection to the first network device is currently lost.

In some embodiments, the first client device may be disposed within the first network. In some cases, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client device, the request via a client broker. In some instances, the one or more brokers may comprise at least one of a local messaging broker or a downstream messaging broker, or the like. In some instances, the local messaging broker may communicatively couple with a control channel associated with the first network. In some cases, the downstream messaging broker may communicatively couple with a control channel associated with one of a second network within which the first network device is located or an intermediate network among one or more intermediate networks between the first network and the second network.

In some instances, each of the control channel associated with the first network, the control channel associated with the second network, and the control channel associated with the intermediate network may be clustered across multiple servers in its respective network. In some cases, the first network device may be determined to be locally accessible by the first broker manager when the first network device is not offline and when the connection to the first network devices is not currently lost. In some instances, the one or more brokers may further comprise a mediator broker. Merely by way of example, in some cases, the mediator broker may comprise at least one of one or more serial line management (“SLM”) mediator brokers, one or more transmission control protocol (“TCP”) mediator brokers, one or more hypertext transfer protocol (“HTTP”) mediator bro-

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kers, one or more secure shell protocol (“SSH”) mediator brokers, or one or more simple network management protocol (“SNMP”) mediator brokers, and/or the like. In some instances, each of at least one SLM mediator broker among the one or more SLM mediator brokers may be configured to mediate multiple connections to multiple client devices regardless of whether the first network device to which it is communicatively coupled is only capable of single client-only connection.

In some cases, one or more of the client broker, the local messaging broker, the downstream messaging broker, or the mediator broker may be modular. In some instances, the client broker may be configured to be interchangeable with other client brokers, each messaging broker may be configured to be interchangeable with other messaging brokers, and the mediator broker may be configured to be interchangeable with other mediator brokers. In some cases, the first broker manager may be communicatively coupled to and may manage at least one of one or more client brokers, one or more messaging brokers, or one or more mediator brokers, and/or the like. In some instances, each client broker may comprise one of a single-port client broker that communicatively couples with a single client device or a multi-port client broker that communicatively couples with each of a plurality of client devices.

According to some embodiments, the method may further comprise, based on a determination that the first network device is not listed within the stored list, performing the following: forwarding, using the first broker manager, the request via at least one of the local messaging broker or the downstream messaging broker; after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that the first network device is offline, updating, using the first broker manager, the stored list to indicate that the first network device is offline, and sending or relaying, using the first broker manager, a message to the first client device indicating that the first network device is offline; and after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that a connection to the first network device is currently lost, updating, using the first broker manager, the stored list to indicate that a connection to the first network device is currently lost, and sending or relaying, using the first broker manager, a message to the first client device indicating that a connection to the first network device is currently lost.

In some instances, the stored list may comprise a subscription table associated with the first broker manager. In some cases, forwarding the request may comprise polling, using the first broker manager, at least one of the local messaging broker or the downstream messaging broker to determine whether a subscription for the first network device already exists. In some instances, the method may further comprise dynamically identifying and creating, using the first broker manager, subscriptions based at least in part on receiving one or more subscription acknowledgement (“sub ack”) messages from one or more intermediate broker managers between the first broker manager and the first network device in one or more of the first network, the third network, or an intermediate network among at least one intermediate network between the first network and the third network, and/or the like. The method may also comprise autonomously filling, using the first broker manager, one or more subscription fields in the subscription table based on the identified and created subscriptions.

In some embodiments, the method may further comprise at least one of: issuing, using the alert manager, a trouble

ticket for the first network device; sending, using the alert manager, a message to a technician to repair at least one of the first network device or the connection to the first network device; or sending, using the alert manager, an alert associated with the first network device to a fault management system; and/or the like.

According to some embodiments, the first client device may be disposed within a fourth network among the plurality of networks. In some cases, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client device, the request via a second broker manager that is locally coupled with the first client device via its client broker and via an upstream messaging broker that is communicatively coupled with a control channel associated with one of the fourth network or an intermediate network among one or more intermediate networks between the first network and the fourth network, the upstream messaging broker being managed by the first broker manager. In some instances, sending or relaying the message to the first client device may comprise relaying, using the first broker manager, the message to the first client device via the upstream messaging broker and via the second broker manager. In some cases, relaying one of the message to the first client device indicating that the first network device is offline or the message to the first device indicating that a connection to the first network device is currently lost may comprise relaying the one of the message to the first client device indicating that the first network device is offline or the message to the first device indicating that a connection to the first network device is currently lost via the second broker manager and via the upstream messaging broker.

In some instances, the stored list may be maintained and updated within a network element database (“NED”). In some cases, the plurality of networks may be separated from each other by firewalls. Merely by way of example, in some cases, the first network device may comprise one of a network switch, an intermediary device, a multiservice provisioning platform, a gateway device, a network node, a router, a network security or firewall appliance, a telephone electronic switching system, an optical network switch and routing platform, a wavelength division multiplexing (“WDM”) -based optical transport network system, a network transmission system, a server, or a user device, and/or the like. In some instances, the stored list may comprise a subscription table associated with the first broker manager. In some cases, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client device, a subscription request for subscribing to the first network device.

In some embodiments, the method may further comprise updating, using the first broker manager, the subscription table based at least in part on received status information associated with at least one of the first network device or the connection to the first network device.

In another aspect, a system may comprise a computing system that is disposed within a first network among a plurality of networks. The computing system may comprise a first broker manager, at least one first processor, and a first non-transitory computer readable medium communicatively coupled to the at least one first processor. The first non-transitory computer readable medium may have stored thereon computer software comprising a first set of instructions that, when executed by the at least one first processor, causes the first broker manager to: receive, from a first client

device, a request to establish a connection with a first network device over at least one network among the plurality of networks; based on a determination that the first network device is listed within a stored list, determine whether any alerts associated with the first network device have been received by an alert manager that is communicatively coupled with the first broker manager, and perform at least one of the following, without polling other broker managers regarding the status of the first network device and without attempting to connect to the first network device via one or more brokers that are managed by the first broker manager: based on a determination that an alert has been received that indicates that the first network device is offline, sending or relaying a message to the first client device indicating that the first network device is offline; or based on a determination that an alert has been received that indicates that a connection to the first network device is currently lost, sending or relaying a message to the first client device indicating that a connection to the first network device is currently lost.

In yet another aspect, a method may comprise receiving, using a first broker manager that is disposed within a first network among a plurality of networks and from the first client device, a subscription request for subscribing to the first network device; and determining, using the first broker manager, whether the first network device is listed within a subscription table. The method may further comprise, based on a determination that the first network device is listed within the subscription table, determining, using the first broker manager, whether any alerts associated with the first network device have been received by an alert manager that is communicatively coupled with the first broker manager, and performing at least one of the following, without polling other broker managers regarding the status of the first network device and without attempting to connect to the first network device via one or more brokers that are managed by the first broker manager: based on a determination that an alert has been received that indicates that the first network device is offline, sending or relaying, using the first broker manager, a message to the first client device indicating that the first network device is offline; based on a determination that an alert has been received that indicates that a connection to the first network device is currently lost, sending or relaying, using the first broker manager, a message to the first client device indicating that a connection to the first network device is currently lost; or based on a determination that the first network device is locally accessible by the first broker manager when the first network device is not offline and when the connection to the first network devices is not currently lost, sending at least one of the message to the first client device indicating that the first network device is offline or the message to the first device indicating that a connection to the first network device is currently lost, without communicatively coupling with a mediator broker between the first broker manager and the first network device, the mediator broker being managed by the first broker manager; and/or the like.

In some embodiments, receiving the subscription request may comprise receiving, using the first broker manager and from the first client device, the subscription request via a client broker. In some cases, the one or more brokers may comprise at least one of an upstream messaging broker, a local messaging broker, or a downstream messaging broker, and/or the like. In some instances, the local messaging broker may communicatively couple with a control channel associated with the first network. In some cases, the downstream messaging broker may communicatively couple with

a control channel associated with one of a second network within which the first network device is located or an intermediate network among one or more intermediate networks between the first network and the second network. In some instances, the upstream messaging broker may communicatively couple with a control channel associated with one of the fourth network or an intermediate network among one or more intermediate networks between the first network and the fourth network, in the case that the first network is disposed between the fourth network and the second network. In some cases, the ID of the second network may comprise at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID, and/or the like, of the second network.

According to some embodiments, the method may further comprise, based on a determination either that the first network device is not listed within the subscription table, performing the following: polling, using the first broker manager, at least one of the upstream messaging broker, the local messaging broker, or the downstream messaging broker to determine whether a subscription for the first network device already exists; dynamically identifying and creating, using the first broker manager, subscriptions based at least in part on receiving one or more subscription acknowledgement (“sub ack”) messages from one or more intermediate broker managers between the first broker manager and the first network device in one or more of the first network, a third network within which the first network device is determined to be located, or an intermediate network among at least one intermediate network between the first network and the third network; autonomously filling, using the first broker manager, one or more subscription fields in the subscription table based on the identified and created subscriptions; after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that the first network device is offline, updating, using the first broker manager, the subscription table to indicate that the first network device is offline, and sending or relaying, using the first broker manager, a message to the first client device indicating that the first network device is offline; and after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that a connection to the first network device is currently lost, updating, using the first broker manager, the subscription table to indicate that a connection to the first network device is currently lost, and sending or relaying, using the first broker manager, a message to the first client device indicating that a connection to the first network device is currently lost.

Various modifications and additions can be made to the embodiments discussed without departing from the scope of the invention. For example, while the embodiments described above refer to particular features, the scope of this invention also includes embodiments having different combination of features and embodiments that do not include all of the above described features.

Specific Exemplary Embodiments

We now turn to the embodiments as illustrated by the drawings. FIGS. 1-5 illustrate some of the features of the method, system, and apparatus for implementing network routing, and, more particularly, to methods, systems, and apparatuses for implementing name-based routing through networks, as referred to above. The methods, systems, and apparatuses illustrated by FIGS. 1-5 refer to examples of different embodiments that include various components and

steps, which can be considered alternatives or which can be used in conjunction with one another in the various embodiments. The description of the illustrated methods, systems, and apparatuses shown in FIGS. 1-5 is provided for purposes of illustration and should not be considered to limit the scope of the different embodiments.

With reference to the figures, FIG. 1 is a schematic diagram illustrating a system 100 for implementing name-based routing through networks, in accordance with various embodiments.

In the non-limiting embodiment of FIG. 1, system 100 may comprise one or more computing systems (“CS”) 105a-105n and 105a'-105n' (collectively, “computing systems 105 or 105'” or “computing systems” or “CS” or the like) that are disposed across a plurality of networks 140a-140n (collectively, “networks 140” or the like), which may be separated from each other by firewalls 160, or the like. Each computing system 105 or 105' may comprise a broker controller or broker manager 110 (that is, computing system 105a comprises broker manager 110a, computing system 105b comprises broker manager 110b, computing system 105n comprises broker manager 110n, computing system 105a' comprises broker manager 110a', computing system 105b' comprises broker manager 110b', computing system 105n' comprises broker manager 110n', and so on). As shown in FIG. 1, each broker manager 110 may include, without limitation, at least one of one or more client broker 115a-115n (collectively, “client brokers 115” or the like), one or more messaging brokers 120 (including, but not limited to, at least one of an upstream messaging broker 120a, a local messaging broker 120b, or a downstream messaging broker 120c, and/or the like), one or more mediator brokers 125a-125n (collectively, “mediator brokers 125” or the like), a subscription table 130, or an alert manager 135 (optional), and/or the like. Merely by way of example, in some cases, each broker manager 110 may include, but is not limited to, at least one of a virtual broker manager, a software-based (“SW”) broker manager, or a broker manager software application (“app”), and/or the like. In some instances, each of the brokers 115-125, as well as the subscription table 130 and alert manager 135, may be implemented as virtual, SW, and/or app components, or the like.

System 100 may further comprise at least one of one or more client devices 145a-145n (collectively, “client devices 145” or the like), one or more network element databases (“NEDs”) 150a-150n (collectively, “NEDs 150” or the like; in some cases, with each NED corresponding to a network (e.g., NED 150a associated with and disposed in network 140a, NED 150b associated with and disposed in network 140b, NED 150n associated with and disposed in network 140n, and so on)), one or more network devices 155a-155n (collectively, “network devices 155” or the like; although shown in FIG. 1 to be disposed only in network 140n, network devices 155 may be disposed throughout networks 140a-140n, or the like), firewalls 160 at edges of networks 140 and/or between networks 140, one or more control channels (“CC”) 165a-165n (collectively, “control channels 165” or “CC” or the like; in some cases, with each CC corresponding to a network (e.g., CC 165a associated with and disposed in network 140a, CC 165b associated with and disposed in network 140b, CC 165n associated with and disposed in network 140n, and so on)), a fault management system 170 (e.g., real-time fault management system (“RFM”) 170, or the like), and/or the like. According to some embodiments, networks 140a-140n and the components described above that may be disposed in networks

140a-140n may be associated with, owned by, and/or operated by (or on behalf of) an entity **175**, including, but not limited to, at least one of an enterprise company, a business entity, a corporate entity, a private entity, a public entity, a healthcare services entity, a governmental entity, or a service provider, and/or the like.

According to some embodiments, network(s) **140a-140n** may each include, without limitation, one of a local area network (“LAN”), including, without limitation, a fiber network, an Ethernet network, a Token-Ring™ network, and/or the like; a wide-area network (“WAN”); a wireless wide area network (“WWAN”); a virtual network, such as a virtual private network (“VPN”); the Internet; an intranet; an extranet; a public switched telephone network (“PSTN”); an infra-red network; a wireless network, including, without limitation, a network operating under any of the IEEE 802.11 suite of protocols, the Bluetooth™ protocol known in the art, and/or any other wireless protocol; and/or any combination of these and/or other networks. In a particular embodiment, the network(s) **140a-140n** may include an access network of the service provider (e.g., an Internet service provider (“ISP”)). In another embodiment, the network(s) **140a-140n** may include a core network of the service provider and/or the Internet.

In some embodiments, disposed within each network **140a-140n** may be a plurality of computing systems **105**, **105'**, and so on, and their corresponding broker managers **110**, **110'**, and so on. For example, as shown in FIG. 1, at least computing systems **105a** and **105a'** may be disposed in first network **140a** (although not shown, computing system **105a''**, **105a'''**, and so on, may also be disposed in the first network **140a**), with each comprising a broker manager **110a**, **110a'**, and so on. In some instances, broker manager **110a** may be a first primary broker manager, which may be elected by the plurality of broker managers in the first network **140a** to be primary publisher in the first network **140a**, while broker manager **110a'** may be a first secondary broker manager among two or more first secondary broker managers (e.g., **110a''**, **110a'''**, etc.) that are each configured to be a secondary publisher that is on hot standby in the first network **140a**. Similarly, broker manager **110b** may be the second primary broker manager that is elected by the plurality of broker managers in the second network **140b** to be primary publisher in the second network **140a**, while broker manager **110b'** may be a second secondary broker manager (among two or more such broker managers) that are each configured to be a secondary publisher that is on hot standby in the second network **140b**. And so on. Being on hot standby, the secondary publisher takes over operations for the primary publisher in its respective network and provides invisible and/or seamless failover, as well as redundancy, in the event that the primary publisher in said network goes offline, non-operational, or otherwise becomes not fully functional, or the like.

In some cases, each client broker **115a-115n** may include, but is not limited to, one of a single-port client broker that communicatively couples with a single client device **145** or a multi-port client broker that communicatively couples with each of a plurality of client devices **145**. In some instances, the one or more client devices **145a-145n** may each include, but is limited to, one of a desktop computer, a laptop computer, a tablet computer, a smart phone, a mobile phone, a probe, a NOC computing system or console, or any suitable device capable of communicating with broker controller **110** via client broker **115**, or the like) via a web-based portal, an application programming interface (“API”), a server, a software application (“app”), or any other suitable

communications interface or protocol, or the like, over network(s) **140**. In some cases, the local messaging broker **120b** for each broker manager **110** may communicatively couple with a control channel **165** associated with its respective network **140**. In some instances, the downstream messaging broker **120c** for each broker manager **110** may communicatively couple with a control channel **165** associated with one of its respective network **140** or a downstream intermediate network among one or more downstream intermediate networks between its respective network and the network within which the network device is disposed or located (in this case, network **140n**, or the like). In some cases, the upstream messaging broker **120a** for each broker manager **110** may communicatively couple with a control channel **165** associated with one of a network within which the client device is disposed if not disposed in its respective network or an upstream intermediate network among one or more upstream intermediate networks between its respective network and the network within which the client device is disposed or located (in this case, network **140a**, or the like), in the case that its respective network is disposed between the network **140a** and the network **140n**.

Merely by way of example, in some cases, the one or more mediator brokers **125** may each include, without limitation, at least one of one or more serial line management (“SLM”) mediator brokers, one or more transmission control protocol (“TCP”) mediator brokers, one or more hypertext transfer protocol (“HTTP”) mediator brokers, one or more secure shell protocol (“SSH”) mediator brokers, or one or more simple network management protocol (“SNMP”) mediator brokers, and/or the like. In some instances, each of at least one SLM mediator broker among the one or more SLM mediator brokers may be configured to mediate multiple connections to multiple client devices regardless of whether the network device **155** to which it is communicatively coupled is only capable of single client-only connection.

In some instances, at least one of the one or more client brokers **115a-115n**, the upstream messaging broker **120a**, the local messaging broker **120b**, the downstream messaging broker **120c**, or the one or more mediator brokers **125a-125n**, and/or the like, may be modular. In some instances, each client broker **115** may be configured to be interchangeable with other client brokers **115**, each messaging broker **120** may be configured to be interchangeable with other messaging brokers **120**, and each mediator broker **125** may be configured to be interchangeable with other mediator brokers **125**. In some cases, each broker manager **110** may be communicatively coupled to/with and may manage at least one of one or more client brokers **115a-115n**, one or more messaging brokers **120a-120c**, or one or more mediator brokers **125a-125n**, and/or the like.

In some cases, each subscription table **130** associated a corresponding broker manager **110** may be maintained and updated within a network element database (e.g., NED **150**, or the like). In some instances, the alert manager **135** may be configured to perform at least one of: receiving alerts or messages indicating that one or more network devices **155** are offline; receiving alerts or messages indicating that a connection to each of one or more network devices **155** is currently lost (or down); issuing a trouble ticket for the one or more network devices **155**; sending a message to a technician to repair at least one of the one or more network devices **155** or the connection to the one or more network devices **155**; or sending an alert associated with each of the one or more network devices **155** to a fault management

system (i.e., feeding alert data into fault management system **170** (e.g., RFM **170**, or the like), or the like); and/or the like. RFM **170** is described in greater detail in U.S. patent application Ser. No. 17/987,316 (the “**316 Application**”), filed Nov. 15, 2022, by Steve Toms et al., entitled, “Real-Time Fault Management (RFM),” which claims priority to U.S. patent application Ser. No. 63/402,812 (the “**812 Application**”), filed Aug. 31, 2022, by Steve Toms et al., entitled, “Real-Time Fault Management (RFM),” the disclosure of each of which is incorporated herein by reference in its entirety for all purposes.

Merely by way of example, in some cases, the one or more network devices **155a-155n** may each include, but is not limited to, one of a network switch, an intermediary device, a multiservice provisioning platform, a gateway device, a network node, a router, a network security or firewall appliance, a telephone electronic switching system, an optical network switch and routing platform, a wavelength division multiplexing (“WDM”)-based optical transport network system, a network transmission system, a server, or a user device, and/or the like. In some instances, each control channel or CC **165a-165n** may be clustered across multiple servers in its respective network **140**, and each CC **165** may serve as a message bus for its respective network **140**. In some cases, each CC **165** may utilize a stream-processing platform, message service, and/or message broker (and their corresponding protocols or the like) including, but not limited to, Apache Kafka®, Tibco®, representational state transfer (“REST”), Apache ActiveMQ®, Java® message service (“JMS”), RabbitMQ®, or HornetQ®, and/or the like.

In some embodiments, in response to receiving a subscription request from a first client device for subscribing to a first network device, each broker manager **110** may be configured to perform at least one of: adding subscription data that is associated with the first network device and that is contained in the subscription request to its respective subscription table **130**, the subscription data comprising a name of the first network device and an identifier (“ID”) of a network within which the first network device (e.g., network device **155a**, or the like) is located (in this case, network **140n**, or the like); based on a determination that the first network device is not locally accessible (i.e., accessible via other broker managers, or the like), forwarding the subscription request to at least one of its respective local control channel (e.g., CC **165a** or **165b**, or the like) via a local messaging broker **120b** that it manages or a downstream local control channel (e.g., CC **165b-165n**, or the like) via a downstream messaging broker **120c** that it manages if elected as a primary publisher in its respective network, and ignoring the subscription request if set as a secondary publisher in its respective network; or based on a determination that the first network device is locally accessible, creating one or more publication/subscription (“pub/sub”) channels in its respective local control channel, and sending a subscription acknowledgement (“sub ack”) message via at least one of an upstream messaging broker **120a** that it manages or the local messaging broker **120b** that it manages; in response to receiving the sub ack message from another broker manager, joining the one or more pub/sub channels, forwarding the sub ack message to a local control channel in an upstream network if elected as a primary publisher in its respective network, and ignoring the sub ack message if set as a secondary publisher in its respective network; or if the first client device is locally accessible to it, sending confirmation of subscription to the first client device via a client broker **115** that it manages, and receiving

and routing one or more commands for the first network device from the first client device via the client broker and via at least one of the local messaging broker, a downstream messaging broker, or a mediator broker that it manages, based at least in part on the subscription data, without routing based on Internet Protocol (“IP”) address of the first network device; and/or the like. In some instances, the ID of the network **140n** may comprise at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID, and/or the like, of the network **140n**.

In operation, computing system **105** or broker manager **110** (collectively, “computing system” or “broker manager” or the like; e.g., computing system **105a** and/or broker manager **110a**, or the like) may receive a subscription request for subscribing to a first network device (e.g., network device **155a**, or the like) from a first client device (e.g., client device **145a**, or the like), in some cases, via a client broker (e.g., client broker **115a**, or the like). The broker manager may determine whether the first network device is listed within a subscription table (e.g., subscription table **130**, or the like). If so, and based on a determination that the first network device is not locally accessible by the first broker manager, the broker manager: may send or relay a message to the first client device indicating at least one of a subscription acknowledgement (“sub ack”) message, a message indicating that one or more publication/subscription (“pub/sub”) channels have been created for the first network device in at least a first network (i.e., network **140a** within which the broker manager **110a** is disposed or located, or the like) and a second network (i.e., network **140n** within which the first network device **155a** is disposed or located, or the like), or a message indicating that one or more intermediate broker managers between the broker manager and the first network device have joined the one or more pub/sub channels; and in response to receiving one or more commands for the first network device from the first client device, may route the one or more commands via at least one of an upstream messaging broker **120a**, a local messaging broker **120b**, or a downstream messaging broker **120c** that is managed by the first broker manager, based at least in part on first subscription data associated with the first network device that is contained in the subscription table **130**, without routing based on IP address of the first network device, the first subscription data comprising a name of the first network device and an ID of the second network within which the first network device is located. If so, and based on a determination that the first network device is locally accessible by the first broker manager (i.e., if broker manager **110n** receives the request, or the like), the broker manager: may send or relay a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands; and in response to receiving the one or more commands for the first network device from the first client device, may route the one or more commands (in some cases, via the client broker if the client device is also disposed within network **140n** and is communicatively coupled to broker manager **110n**, or the like; or via the upstream messaging broker **120a** if the client device is disposed in an upstream network (e.g., network **140a-140(n-1)**, or the like) and via a mediator broker (e.g., mediator broker **125a**, or the like) based at least in part on second subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device, the second subscription data comprising the name of the first

network device and an ID of the first network, the mediator broker being managed by the first broker manager.

Based on a determination that the first network device is not listed within the subscription table, the broker manager: may poll at least one of the upstream messaging broker **120a**, the local messaging broker **120b**, or the downstream messaging broker **120c** to determine whether a subscription for the first network device already exists; may dynamically identify and create subscriptions based at least in part on receiving one or more subscription acknowledgement (“sub ack”) messages from one or more intermediate broker managers between the first broker manager and the first network device in one or more of the first network, a third network within which the first network device is determined to be located, or an intermediate network among at least one intermediate network between the first network and the third network; may autonomously fill one or more subscription fields in the subscription table based on the identified and created subscriptions; may send or relay a message to the first client device indicating at least one of a sub ack message, a message indicating that one or more publication/subscription (“pub/sub”) channels have been created for the first network device in at least the first network and the third network, or a message indicating that one or more intermediate broker managers between the first broker manager and the first network device have joined the one or more pub/sub channels; and in response to receiving one or more commands for the first network device from the first client device, may route the one or more commands via at least one of the upstream messaging broker, the local messaging broker, or the downstream messaging broker, based at least in part on third subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device, the third subscription data comprising a name of the first network device and an ID of the third network within which the first network device is located. As shown in FIG. 1, name-based routing utilizes upstream and downstream communications and routing that can pass through firewalls **160** without having to open up ports and firewalls (as depicted by the communications lines between upstream and downstream messaging brokers **220a** and **220c** of broker managers in different networks **140** passing through firewalls **160** between said networks **140**, or the like)

In some aspects, the name-based routing described herein may enable one or more of the following features or characteristics (or otherwise provides the following functionalities): (a) provides virtual direct connection between a client and a device in a different network, which is separated from the client network by firewall, or the like; (b) can read the device from anywhere in the network(s); (c) acts like a “layer 4 extension cord”; (d) can pass through firewalls without having to open up ports and firewalls (thereby providing secure routing without requiring changes to the firewalls and ports for each routing instance); (e) can route by network and name rather than by IP address (which is limited in number, resulting in potential IP conflicts, or the like; compared with name-based routing that may utilize different naming conventions across networks and may likely use geographical identifiers in their names, or the like).

These and other functions of the system **100** (and its components) are described in greater detail below with respect to FIGS. 2-4.

FIGS. 2A and 2B (collectively, “FIG. 2”) are schematic diagrams illustrating various non-limiting examples **200** and **200'** of broker managers and their interconnections with

other components during implementation of name-based routing through networks, in accordance with various embodiments. FIG. 2A depicts a broker controller or manager **210** and a plurality of brokers that it controls or manages, as well as a stream-processing platform, message service, and/or message broker (and their corresponding protocols or the like) that each broker uses for communicating with other devices. FIG. 2B depicts interaction between two broker managers **210a** and **210b** that are disposed within different networks **240a** and **240b** that are separated by a firewall **260**, as well as the brokers that each broker manager controls or manages and the corresponding stream-processing platform, message service, and/or message broker (and their corresponding protocols or the like) used for communicating with other devices.

As shown in the non-limiting embodiment **200** of FIG. 2A, broker controller or manager **210** may control or manage at least one of a client broker **215**, one or more messaging brokers **220** (including, but not limited to, at least one of an upstream broker **220a**, a local broker **220b**, and/or a downstream broker **220c**, and/or the like), or one or more mediator brokers **225a-225b**, and/or the like. Client broker **215** may communicatively couple with client device **245a**, using communications protocol, including, but not limited to, transmission control protocol (“TCP”), or the like. In some cases, client broker **215** may include, but is not limited to, one of a single-port client broker that communicatively couples with a single client device (e.g., client device **245a**, or the like) or a multi-port client broker that communicatively couples with each of a plurality of client devices (not shown). In some instances, the client device **245a** may include, but is limited to, one of a desktop computer, a laptop computer, a tablet computer, a smart phone, a mobile phone, a probe, or a NOC computing system or console, and/or the like.

Each of the one or more messaging brokers **220** may communicatively couple with a control channel associated with a network (e.g., as shown in FIGS. 1 and 3A-3C, or the like), with the upstream broker **220a** communicatively coupling with a control channel associated with an upstream network, while the local broker **220b** communicatively couples with a local control channel associated with the network in which the broker manager **210** is disposed or located, and the downstream broker **220c** communicatively couples with a control channel associated with a downstream network. Herein, the term “local” is in relation to the broker controller or manager **210**, while the term “downstream” refers to networks or components thereof that are further along in a direction from the client device toward a network device with/to which the client device is trying to establish connection or trying to subscribe (in some cases, the client device is disposed in a central network, a demilitarized zone (“DMZ”), or a remote network, while the network device is disposed in an edge network or network edge, or the like, such as shown in FIGS. 2B, 3B, and 3C, or the like), and the term “upstream” refers to networks or components thereof that are further along in a direction from the network device toward the client device. Although FIG. 2A depicts Apache Kafka® as the stream-processing platform, message service, and/or message broker (and their corresponding protocols or the like) that each messaging broker **220** uses for communicatively coupling with their respective control channels, the various embodiments are not so limited, and any suitable stream-processing platform, message service, and/or message broker (and their corresponding protocols or the like) may be used, including, but not limited to, Apache Kafka®, Tibco®, representational

state transfer (“REST”), Apache ActiveMQ®, Java® message service (“JMS”), RabbitMQ®, or HornetQ®, and/or the like.

Merely by way of example, in some cases, the one or more mediator brokers **225** may each include, without limitation, at least one of one or more serial line management (“SLM”) mediator brokers (e.g., mediator broker **225a**, or the like), one or more transmission control protocol (“TCP”) mediator brokers (e.g., mediator broker **225b**, or the like), one or more hypertext transfer protocol (“HTTP”) mediator brokers (not shown), one or more secure shell protocol (“SSH”) mediator brokers (not shown), or one or more simple network management protocol (“SNMP”) mediator brokers (not shown), and/or the like. In some instances, each of at least one SLM mediator broker among the one or more SLM mediator brokers may be configured to mediate multiple connections to multiple client devices regardless of whether the network device to which it is communicatively coupled is only capable of single client-only connection. For example, although 5E switches (e.g., 5E switch named “ABC” **255a**, as shown in FIG. 2A, or the like) each only allow one client to connect to it, SLM mediator broker **225a** allows for or mediates multiple connections to multiple clients, and thus overcomes this design or hardware limitation of 5E switches. Also, because 5E switches are incapable of communicating via protocols such as TCP, or the like, an intermediary device (e.g., T40 switch **280a**, which is capable of connecting up to 40 switches, or the like) must be used that translates TCP communications from/to a client device with SLM communications to/from the 5E switch.

In some instances, at least one of the client broker **215**, the upstream messaging broker **220a**, the local messaging broker **220b**, the downstream messaging broker **220c**, or the one or more mediator brokers **225a-225b**, and/or the like, may be modular. In some instances, client broker **215** may be configured to be interchangeable with other client brokers **215**, each messaging broker **220** may be configured to be interchangeable with other messaging brokers **220**, and each mediator broker **225** may be configured to be interchangeable with other mediator brokers **225**. In some cases, broker manager **210** may be communicatively coupled to/with and may manage at least one of one or more client brokers **215a-215n**, one or more messaging brokers **220a-220c**, or one or more mediator brokers **225a-225n**, and/or the like.

In a non-limiting example, client **245a** may request subscription to 5E switch “ABC” **255a**, by sending such request to broker manager **210**, which receives such request via client broker **215** using TCP, or the like. In response to receiving the request, broker manager **210** may determine whether a subscription already exists for 5E switch “ABC” **255a**, based on its subscription table **230**. In this case, broker manager **210** may determine, based on its subscription table **230**, that a subscription exists for 5E switch “ABC” **255a**, with subscription data associated with 5E switch “ABC” **255a** indicating name of the network device (in this case, “ABC” or the like), network in which the device is disposed or located (in this case, the same network as the broker manager **210**, or the like), and other data, including, but not limited to, connection via SLM mediator broker **225a** and intermediary network device **280a** (in this case, T40 switch **280a**, or the like, although not limited to such switches). Based on such determination, the broker manager **210** may send a message to client device **245a** confirming subscription to 5E switch “ABC” **255a** and/or a message to client device **245a** indicating at least one of that a connection with 5E switch “ABC” **255a** has been established or that 5E

switch “ABC” **255a** is ready to receive commands; and in response to receiving one or more commands for 5E switch “ABC” **255a** from client device **245a**, may route the one or more commands via client broker **215** (using TCP) and via SLM mediator broker **225a** (using TCP/SLM) based at least in part on the subscription data associated with 5E switch “ABC” **255a** that is contained in subscription table **230**, without routing based on IP address of 5E switch “ABC” **255a**. Any replies from 5E switch “ABC” **255a** would travel in the reverse direction through the intermediary device **280a**, the mediator broker **225a**, the broker manager **210**, and the client broker **215**.

In another non-limiting example, client **245a** may request subscription to provisioning platform “Cisco15454” **255b**, by sending such request to broker manager **210**, which receives such request via client broker **215** using TCP, or the like. In response to receiving the request, broker manager **210** may determine a subscription already exists for provisioning platform “Cisco15454” **255b**, based on its subscription table **230**. In this case, broker manager **210** may determine, based on its subscription table **230**, that a subscription exists for provisioning platform “Cisco15454” **255b**, with subscription data associated with provisioning platform “Cisco15454” **255b** indicating name of the network device (in this case, “Cisco15454” or the like), network in which the device is disposed or located (in this case, the same network as the broker manager **210**, or the like), and other data, including, but not limited to, connection via TCP mediator broker **225b**. Based on such determination, the broker manager **210** may send a message to client device **245a** confirming subscription to provisioning platform “Cisco15454” **255b** and/or a message to client device **245a** indicating at least one of that a connection with provisioning platform “Cisco15454” **255b** has been established or that provisioning platform “Cisco15454” **255b** is ready to receive commands; and in response to receiving one or more commands for provisioning platform “Cisco15454” **255b** from client device **245a**, may route the one or more commands via client broker **215** (using TCP) and via TCP mediator broker **225b** (using TCP) based at least in part on the subscription data associated with provisioning platform “Cisco15454” **255b** that is contained in subscription table **230**, without routing based on IP address of provisioning platform “Cisco15454” **255b**. Any replies from 5E switch “ABC” **255a** would travel in the reverse direction through the mediator broker **225b**, the broker manager **210**, and the client broker **215**.

As shown in the non-limiting embodiment **200'** of FIG. 2B, broker managers **210a** and **210b** may each control or manage at least one of one or more client brokers 1 to N **215a-215n**, one or more messaging brokers **220** (including, but not limited to, at least one of an upstream broker **220a**, a local broker **220b**, and/or a downstream broker **220c**, and/or the like), one or more mediator brokers 1 to N **225a-225n**, a subscription table **230**, or an alert manager **235**, and/or the like. Client broker **215** may communicatively couple with client device **245a**, using communications protocol, including, but not limited to, transmission control protocol (“TCP”), or the like. In some cases, client broker **215** may include, but is not limited to, one of a single-port client broker that communicatively couples with a single client device (e.g., client device **245a**, or the like) or a multi-port client broker that communicatively couples with each of a plurality of client devices (not shown).

As shown in FIG. 2B, broker manager **210a** that is disposed or located within network **240a** (which may be a DMZ or remote network, or the like) may act as a central

controller that manages subscriptions and routes traffic between client brokers **215** and mediator brokers **225**, while also managing sending of alerts as necessary via alert manager **235**, or the like. Alert manager **235** may be responsible for tracking loss of connection to the mediators and reporting those alerts to the central controller, even if the alert manager is in a different network (e.g., alert manager **235** that is communicatively coupled to broker manager **210b** that is disposed in network edge **240b** may send alerts to broker manager **210a** that is disposed in DMZ **240a** and that is acting as the central controller, or the like). Client devices **245** (e.g., client **245b** or probe **245c**, or the like) may authenticate through the client broker **215**, and then may subscribe to virtual channels on one or more devices **255** connected (directly, or indirectly via intermediary devices **280**, or the like) to the broker managers **210** via mediator brokers **225**.

In a non-limiting example, client device **245b** may request subscription to 5E switch “EFG” **255c**, by sending such request to broker manager **210a**, which receives such request via client broker N **215n** using TCP (in some cases via a client API, or the like), or the like. In response to receiving the request, broker manager **210a** may determine whether a subscription already exists for 5E switch “EFG” **255c**, based on its subscription table **230**. In this case, broker manager **210a** may determine, based on its subscription table **230**, that a subscription exists for 5E switch “EFG” **255c**, with subscription data associated with 5E switch “EFG” **255c** indicating name of the network device (in this case, “EFG” or the like), network in which the device is disposed or located (in this case, a network that is different from the network within which the broker manager **210a** is disposed or located (e.g., network edge **240n**, or the like), or the like), and other data, including, but not limited to, connection via downstream messaging broker **220c**, upstream messaging broker **220a** of broker manager **210b** that is disposed in network edge **240n**, mediator broker **1 225a** of broker manager **210b**, and intermediary network devices **280b** and **280c** (in this case, DT-6061 network switch **280b** and DT-4000 network switch **280c**, or the like, although not limited to such switches). Alternatively, the other data in subscription table **230** of broker manager **210a** may include, but is not limited to, connection via downstream messaging broker **220c**, control channel of network edge **240n** (not shown), and/or broker manager **210b**, and/or the like. Based on such determination, the broker manager **210a** may send a message to client device **245b** confirming subscription to 5E switch “EFG” **255c** and/or a message to client device **245b** indicating at least one of that a connection with 5E switch “EFG” **255c** has been established or that 5E switch “EFG” **255c** is ready to receive commands; and in response to receiving one or more commands for 5E switch “EFG” **255c** from client device **245b**, may route the one or more commands via client broker N **215n** (using TCP), via downstream messaging broker **220c** (using Kafka Pub/Sub, or the like), through firewall **260** between DMZ **240a** and network edge **240n**, and via broker manager **210b** in network edge **240n**, which may include routing via upstream messaging broker **220a** of broker manager **210b** and via mediator broker **1 225a** of broker manager **210b** (using TCP/SLM) based at least in part on the subscription data associated with 5E switch “EFG” **255c** that is contained in its subscription table **230**, without routing based on IP address of 5E switch “EFG” **255c**. Network switch DT-6061 **280b** may relay the one or more commands to switch DT-4000 **280c** using TCP (or the like), while switch DT-4000 **280c** may relay the one or more commands to 5E switch “EFG” **255c** using BX.25

or dynamic host configuration protocol (“DHCP”) (or the like). Any replies from 5E switch “EFG” **255c** would travel in the reverse direction through the intermediary devices **280b** and **280c**, the mediator broker **1 225a** of broker manager **210b**, the broker manager **210b**, the upstream messaging broker **220a** of broker manager **210b**, the downstream messaging broker **220c** of broker manager **210a**, the broker manager **210a**, and the client broker N **215n** of broker manager **210a**.

In another non-limiting example, client device **245b** may request subscription to 5E switch “JKL” **255d**, by sending such request to broker manager **210a**, which receives such request via client broker N **215n** using TCP (in some cases via a client API, or the like), or the like. In response to receiving the request, broker manager **210a** may determine whether a subscription already exists for 5E switch “JKL” **255d**, based on its subscription table **230**. In this case, broker manager **210a** may determine, based on its subscription table **230**, that a subscription exists for 5E switch “JKL” **255d**, with subscription data associated with 5E switch “JKL” **255d** indicating name of the network device (in this case, “JKL” or the like), network in which the device is disposed or located (in this case, a network that is different from the network within which the broker manager **210a** is disposed or located (e.g., network edge **240n**, or the like), or the like), and other data, including, but not limited to, connection via downstream messaging broker **220c**, upstream messaging broker **220a** of broker manager **210b** that is disposed in network edge **240n**, mediator broker N **225n** of broker manager **210b**, and intermediary network device **280d** (in this case, T40 switch **280d**, or the like, although not limited to such switches). Alternatively, the other data in subscription table **230** of broker manager **210a** may include, but is not limited to, connection via downstream messaging broker **220c**, control channel of network edge **240n** (not shown), and/or broker manager **210b**, and/or the like. Based on such determination, the broker manager **210a** may send a message to client device **245b** confirming subscription to 5E switch “JKL” **255d** and/or a message to client device **245b** indicating at least one of that a connection with 5E switch “JKL” **255d** has been established or that 5E switch “JKL” **255d** is ready to receive commands; and in response to receiving one or more commands for 5E switch “JKL” **255d** from client device **245b**, may route the one or more commands via client broker N **215n** (using TCP), via downstream messaging broker **220c** (using Kafka Pub/Sub, or the like), through firewall **260** between DMZ **240a** and network edge **240n**, and via broker manager **210b** in network edge **240n**, which may include routing via upstream messaging broker **220a** of broker manager **210b** and via mediator broker N **225n** of broker manager **210b** (using TCP/SLM) based at least in part on the subscription data associated with 5E switch “JKL” **255d** that is contained in subscription table **230**, without routing based on IP address of 5E switch “JKL” **255d**. Network switch T40 **280d** may relay the one or more commands to 5E switch “JKL” **255d** using BX.25 or DHCP (or the like). Any replies from 5E switch “JKL” **255d** would travel in the reverse direction through the intermediary device **280d**, the mediator broker N **225n** of broker manager **210b**, the broker manager **210b**, the upstream messaging broker **220a** of broker manager **210b**, the downstream messaging broker **220c** of broker manager **210a**, the broker manager **210a**, and the client broker N **215n** of broker manager **210a**.

According to some embodiments, broker manager **210a** in DMZ **240a** may communicatively couple with broker manager **210b** in network edge **240n** either via downstream

messaging broker **220c** of broker manager **210a** in DMZ **240a** communicatively coupling with upstream messaging broker **220a** of broker manager **210b** in network edge **240n** (such as shown in FIG. 2B) or via downstream messaging broker **220c** of broker manager **210a** in DMZ **240a** communicatively coupling with local messaging broker **220b** of broker manager **210b** in network edge **240n** via the control channel of network edge **240n** (not shown in FIG. 2B). Also, in alternative embodiments, although not shown in FIG. 2, instead of communicatively coupling via messaging brokers **220**, broker manager **210a** in DMZ **240a** may communicatively couple with broker manager **210b** in network edge **240n** via a mediator broker **225** of broker manager **210a** and via a client broker **215** of broker manager **210b** (in some cases, via the control channel of network edge **240n** (not shown in FIG. 2B)), or the like.

In yet another non-limiting example, probe **245c** may request subscription to 5E switch “EFG” **255c**, by sending such request to broker manager **210b**, which receives such request via client broker N **215n** using TCP, or the like. In response to receiving the request, broker manager **210b** may determine whether a subscription already exists for 5E switch “EFG” **255c**, based on its subscription table **230**. In this case, broker manager **210b** may determine, based on its subscription table **230**, that a subscription exists for 5E switch “EFG” **255c**, with subscription data associated with 5E switch “EFG” **255c** indicating name of the network device (in this case, “EFG” or the like), network in which the device is disposed or located (in this case, the same network as the broker manager **210b** (e.g., network edge **240n**, or the like), or the like), and other data, including, but not limited to, connection via mediator broker **1225a** and intermediary network devices **280b** and **280c** (in this case, DT-6061 network switch **280b** and DT-4000 network switch **280c**, or the like, although not limited to such switches). Based on such determination, the broker manager **210b** may send a message to probe **245c** confirming subscription to 5E switch “EFG” **255c** and/or a message to probe **245c** indicating at least one of that a connection with 5E switch “EFG” **255c** has been established or that 5E switch “EFG” **255c** is ready to receive commands; and in response to receiving one or more commands for 5E switch “EFG” **255c** from probe **245c**, may route the one or more commands via client broker N **215n** (using TCP) and via mediator broker **1225a** (using TCP/SLM) based at least in part on the subscription data associated with 5E switch “EFG” **255c** that is contained in its subscription table **230**, without routing based on IP address of 5E switch “EFG” **255c**. Network switch DT-6061 **280b** may relay the one or more commands to switch DT-4000 **280c** using TCP (or the like), while switch DT-4000 **280c** may relay the one or more commands to 5E switch “EFG” **255c** using BX.25 or DHCP (or the like). Any replies from 5E switch “EFG” **255c** would travel in the reverse direction through the intermediary devices **280b** and **280c**, the mediator broker **1225a**, the broker manager **210b**, and the client broker N **215n**.

In still another non-limiting example, probe **245c** may request subscription to 5E switch “JKL” **255d**, by sending such request to broker manager **210b**, which receives such request via client broker N **215n** using TCP, or the like. In response to receiving the request, broker manager **210b** may determine whether a subscription already exists for 5E switch “JKL” **255d**, based on its subscription table **230**. In this case, broker manager **210b** may determine, based on its subscription table **230**, that a subscription exists for 5E switch “JKL” **255d**, with subscription data associated with 5E switch “JKL” **255d** indicating name of the network

device (in this case, “JKL” or the like), network in which the device is disposed or located (in this case, the same network as the broker manager **210b** (e.g., network edge **240n**, or the like), or the like), and other data, including, but not limited to, connection via mediator broker N **225n** and intermediary network device **280d** (in this case, T40 switch **280d**, or the like, although not limited to such switches). Based on such determination, the broker manager **210b** may send a message to probe **245c** confirming subscription to 5E switch “JKL” **255d** and/or a message to probe **245c** indicating at least one of that a connection with 5E switch “JKL” **255d** has been established or that 5E switch “JKL” **255d** is ready to receive commands; and in response to receiving one or more commands for 5E switch “JKL” **255d** from probe **245c**, may route the one or more commands via client broker N **215n** (using TCP) and via mediator broker N **225n** (using TCP/SLM) based at least in part on the subscription data associated with 5E switch “JKL” **255d** that is contained in subscription table **230**, without routing based on IP address of 5E switch “JKL” **255d**. Network switch T40 **280d** may relay the one or more commands to 5E switch “JKL” **255d** using BX.25 or DHCP (or the like). Any replies from 5E switch “JKL” **255d** would travel in the reverse direction through the intermediary device **280d**, the mediator broker N **225n**, the broker manager **210b**, and the client broker N **215n**.

In some embodiments, broker controller or managers **210**, **210a**, and **210b**, client brokers **215** and **215a-215n**, upstream messaging brokers **220a**, local messaging brokers **220b**, downstream messaging brokers **220c**, mediator brokers **225a-225n**, subscription tables **230**, alert managers **235**, networks **240a** and **240b**, clients or probes **245a-245c**, network devices **255a-255c**, and firewall **260** of FIG. 2 may be similar, if not identical, to broker managers **110**, **110a-110n**, and **110a'-110n'**, client brokers **115a-115n**, upstream messaging brokers **120a**, local messaging brokers **120b**, downstream messaging brokers **120c**, mediator brokers **125a-125n**, subscription tables **130**, alert managers **135**, networks **140a-140n**, clients devices **145a-145n**, network devices **155a-155n**, and firewalls **160**, respectively, of system **100** of FIG. 1, and the description of these components of system **100** of FIG. 1 are similarly applicable to the corresponding components of FIG. 2.

These and other functions of the examples **200** and **200'** (and their components) are described in greater detail below with respect to FIGS. 1, 3, and 4.

FIGS. 3A-3C (collectively, “FIG. 3”) are schematic diagrams illustrating a non-limiting set of examples **300** of a plurality of broker managers and their interconnections with other components across a plurality of networks during implementation of name-based routing through networks, in accordance with various embodiments.

As shown in the non-limiting embodiment **300** of FIG. 3, broker managers A **310a** and B **310b** may be disposed or located within central network **310a** (also referred to as “enterprise network” or the like), while broker managers C **310c** and D **310d** may be disposed or located within remote network **310b**, and broker managers X **310x** and Y **310y** may be disposed or located within edge network **310c**, with each of networks **310a-310c** comprising its respective control channel **365a-365c**, and with the networks **340** separated from each other (or at least from upstream/downstream network pairs) by firewall(s) **360**. For simplicity of illustration, the example workflow(s) described below involves a client (e.g., client device **345**, or the like), a network device (e.g., T40/5E switch “ABC” **355**, or the like), and a NED (e.g., NED **350**, or the like). In some cases, each subscription

table S associated a corresponding broker manager **310** may be maintained and updated within a network element database (e.g., NED **350**, or the like).

In some embodiments, broker controller or managers **310a**, **310b**, **310c**, **310d**, **310x**, and **310y**, client brokers (denoted by “C” blocks), upstream messaging brokers (denoted by “U” blocks), local messaging brokers (denoted by “L” blocks), downstream messaging brokers (denoted by “D” blocks), mediator brokers (denoted by “M” blocks), networks **340a-340c**, client device **345**, NED **350**, network device **355**, and firewall **360** of FIG. **3** may be similar, if not identical, to broker managers **110**, **110a-110n**, and **110a'-110n'**, client brokers **115a-115n**, upstream messaging brokers **120a**, local messaging brokers **120b**, downstream messaging brokers **120c**, mediator brokers **125a-125n**, networks **140a-140n**, clients devices **145a-145n**, NED **150**, network devices **155a-155n**, and firewalls **160**, respectively, of system **100** of FIG. **1**, and the description of these components of system **100** of FIG. **1** are similarly applicable to the corresponding components of FIG. **3**.

With reference to the non-limiting example of FIG. **3A**, upon or after start up or initialization, broker manager X **310x**, which is disposed in edge network **340c**, may bring up or initialize at least one of one or more configured mediator brokers M, one or more client brokers C, and/or one or more messaging brokers U, L, and/or D, and/or the like. Broker manager X **310x** may then connect to its local control channel **365c**, via its local messaging broker L, and may connect to an upstream control channel **365b** in remote network **340b** (which is a network upstream of edge network **340c**), via its upstream messaging broker U. Broker manager X **310x** may send a “Hello” message on local control channel **365c**, via its local messaging broker L. Broker manager Y **310y**, which is also disposed in edge network **340c**, may receive the “Hello” message, may mark the presence of broker manager X **310x**, and may send a “Hello Ack” (or “Hello Acknowledgement”) message on local control channel **365c**, via its local messaging broker L. Broker manager X **310x** may receive the “Hello Ack” message from broker manager Y **310y** and may mark presence of broker manager Y **310y**.

Broker manager X **310x** or broker manager Y **310y** may call for an election for establishment which will be primary publisher in edge network **340c**. For simplicity of illustration, broker manager X **310x** and broker manager Y **310y** agree that broker manager X **310x** will become primary publisher, and similarly, broker manager C **310c** in remote network **340b** and broker manager A **310a** in central network **340a** are elected primary publishers in their respective networks.

Broker manager X **310x** may send a “Hello” message to upstream control channel **365b** in remote network **340b**, via its upstream messaging broker U. Broker manager C **310c** and broker manager D **310d** may mark the presence of broker manager X **310x**, and may send “Hello Ack” messages on their local control channel **365b**. Broker manager X **310x** may receive the “Hello Ack” messages on the upstream control channel **365b** in remote network **340b**, via its upstream messaging broker U, and may mark the presence of both broker manager C **310c** and broker manager D **310d**. Broker manager X **310x** is now ready to begin processing requests. Likewise, the other broker managers **310** perform similar processes as part of their start-up or initialization operations, and/or in response to detected changes in their respective network(s) and/or upstream/downstream network(s) **340**, or the like.

Turning to the non-limiting example of FIG. **3B**, client device **345**, which is disposed in central network **340a**, may send a subscription request for device or network device “ABC” **355** (e.g., T40/5E switch “ABC” **355**, or the like). Broker manager A **310a**, which is also disposed in central network **340a**, may receive the subscription request via one of its client brokers C, and may add the subscription (i.e., for network device “ABC” or the like) to its subscription or subs table “S” (similar to subscription tables or “S” **130** and **230** in FIGS. **1** and **2**, or the like). Broker manager A **310a** does not know device ABC **355** locally, so may send the request to its local control channel **365a**, via its local messaging broker L. Broker manager b **310b**, which is also disposed in central network **340a**, may receive the subscription request on local control channel **365a**, via its local messaging broker L. Because it does not know device ABC **355** locally, and because it is not the primary publisher for central network **340a**, broker manager B **310c** may drop or ignore the subscription request.

Broker manager C **310c**, which is disposed in remote network **340b**, may receive the subscription request on upstream control channel **365a** in central network **340b**, via its upstream messaging broker U. Because it does not know device ABC **355** locally, and because it is the primary publisher for remote network **340b**, broker manager C **310c** may store the subscription request in its subs table S (similar to subscription tables or “S” **130** and **230** in FIGS. **1** and **2**, or the like), and may forward the request to local control channel **365b**, via its local messaging broker L. Broker manager D **310d**, which is also disposed in remote network **340b**, may receive the subscription request on upstream control channel **365a** in central network **340b**, via its upstream messaging broker U. Because it does not know device ABC **355** locally, and because it is not the primary publisher for remote network **340b**, broker manager D **310d** may store the subscription or sub in its subs table S, without forwarding the request on local control channel **365b**. Broker manager D **310d** may receive the subscription request again from broker manager C **310c** on local control channel **365b**, via its local messaging broker L. Because it does not know device ABC **355** locally, and because it is not the primary publisher for remote network **340b**, broker manager D **310d** may drop or ignore the subscription request.

Broker manager Y **310y** may receive the subscription request on upstream control channel **365b** in remote network **340b**, via its upstream messaging broker U. Because it does not know device ABC **355** locally, and because it is not the primary publisher for edge network **340c**, broker manager Y **310y** may store the subscription or sub in its subs table S, without forwarding the request on local control channel **365c**. Broker manager X **310x** may receive the subscription request on upstream control channel **365b** in remote network **340b**, via its upstream messaging broker U. Broker manager X **310x** knows device ABC locally, and because it is the primary publisher in edge network **340c**, it may store the subscription request in its subs table S, may create the pub/sub channels in upstream control channel **365b** in remote network **340b**, and may send a “Sub Ack” (or “Sub Acknowledgement”) message together with channel information on upstream control channel **365b** in remote network **340b**, via its upstream messaging broker U. Broker manager X **310x** may also create the pub/sub channels local control channel **365c**, and may send the “Sub Ack” message to local control channel **365c**, via its local messaging broker L. Broker manager Y **310y** may receive the “Sub Ack” mes-

sage, and may join the publisher or pub/sub channels on upstream control channel **365b** and/or local control channel **365c**.

Broker managers **C 310c** and **D 310d** may receive the “Sub Ack” message on their local control channel **365b**, via their respective local messaging broker **L**, and may create and join the pub/sub channels on local control channel **365b**. Broker manager **C 310c** is the primary publisher, so it forwards the “Sub Ack” message to upstream control channel **365a** in central network **340b**, via its upstream messaging broker **U**. Broker managers **C 310c** and **D 310d** may join the pub/sub channels on upstream control channel **365a**.

Broker managers **A 310a** and **B 310b** may receive the “Sub Ack” message on their local control channel **365c**, via their respective local messaging broker **L**. Broker manager **A 310a** may then forward any traffic from the Pub/Sub channel to its local (TCP) client broker **C** where the sub request originated. Broker manager **A 310a** may send confirmation of subscription to client device **345** via client broker **C**.

Referring to the non-limiting example of FIG. 3C, client device **345** may send one or more commands. Broker manager **A 310a** may receive the one or more commands from client device **345** and may forward the one or more commands to local “ABC Send” channel **385a**, via its local messaging broker **L**. Broker manager **b 310b** may receive the one or more commands on local “ABC Send” channel **385a**, via its local messaging broker **L**, and may ignore them as it is not the primary publisher.

Broker managers **C 310c** and **D 310d** may receive the one or more commands on upstream “ABC Send” channel **385a**, via their respective upstream messaging broker **U**. Broker manager **C 310c** may forward the one or more commands to local “ABC Send” channel **385b**. Broker manager **D 310d** may ignore the one or more commands as it is not the primary publisher.

Broker managers **X 310x** and **Y 310y** may receive the one or more commands on upstream “ABC Send” channel **385b**, via their respective upstream messaging broker **U**. Broker manager **X 310x** knows device **ABC 355** locally, so it may send the one or more commands to device **ABC 355**, via its mediator broker **M**. In some cases, broker manager **X 310x** may also forward the one or more commands to is “ABC Send” channel **385c**, via its local messaging broker **L**. Broker manager **Y 310y** is not the primary publisher and does not know device **ABC** locally, so it ignores the one or more commands.

Broker manager **X 310x** may receive a response from device **ABC 355**, via its mediator broker **M**. Broker manager **X 310x** is the primary publisher, so it may send the response to both local “ABC Receive” channel **390c**, via its local messaging broker **L**, and upstream “ABC Receive” channel **390b**, via its upstream messaging broker **U**. In cases of broker manager **X 310x** failing, operations may failover to broker manager **Y 310y** as the secondary publisher (which is configured to be on hot standby) in edge network **340c**, and thus would result in broker manager **Y 310y** attempting to establish direct communication with device **ABC 355**, via its mediator broker **M** (as denoted in FIG. 3C by the dash-lined double arrows between device **ABC 355** and mediator broker **M** of broker manager **Y 310y**, or the like).

Broker managers **C 310c** and **D 310d** may receive response on local “ABC Receive” channel **390b**, via their respective local messaging broker **L**. Neither has a local subscription, so broker manager **C 310c**, as the primary publisher for remote network **340b**, may forward the

response to upstream “ABC Receive” channel **390a**, via its upstream messaging broker **U**. Broker manager **D 310d** may ignore the response.

Broker managers **A 310a** and **B 310b** may receive the response on local “ABC Receive” channel **390a**, via their respective local messaging broker **L**. Broker manager **A** has a local subscription, so it may send the response to client device **345**, via its client broker **C**. Broker manager **B 310b** may ignore the response.

The workflow of FIGS. 3A-3C are merely illustrative, and are not limited to the particular processes described above. Rather, any suitable alternative processes may be implemented based on name-based routing in accordance with the various embodiments described herein throughout.

Further, although some commands and messages (such as “Hello” message, “Hello Ack” message, “Subscribe” request, “Commands,” etc.) are specifically described, these are not the only messages or commands that may be used during implementation of name-based routing. In some cases, the “Hello” message is used by a broker manager to announce that it is alive; if sent through an upstream messaging broker **U**, it must include “Neighbor Relation” parameter set to “DOWNSTREAM,” and if sent through a local messaging broker **L**, neighbor adjacency may be calculated by the neighbor receiving the “Hello” message. In some instances, the “Hello Ack” message may be used to acknowledge receipt of the “Hello” message from a neighbor; if the “Hello” message was received by an upstream messaging broker **U**, it must include the “Neighbor Relation” parameter set to “DOWNSTREAM,” otherwise the broker manager may calculate the neighbor relation based on which broker it receives the “Hello Ack” message from. In some cases, the “Subscribe” request may be used to request a new subscription to a device. In some instances, the “Subscribe Ack” message may be used to confirm access to a device from the previous “Subscribe” request; this confirmation may also contain information regarding how to communicate with the device (e.g., which Kafka channels or pub/sub channels to send and receive data to and from the device). In some cases, the “Subscribe NACK” message may be used to indicate that subscription to the device has failed, in some cases, because the device has been marked as in alarm or in alert by an alert manager, or the like. In some instances, the “Unsubscribe” command or request may be used to request to cancel a subscription from a client to a device. In some cases, the “Unsubscribe Ack” message may be used to confirm that the subscription has been cancelled. In some instances, the “Local Device Configuration Request” request may be used by a broker manager to request its upstream neighbors to obtain the local devices for a particular mediator’s subnet. In some cases, the “Local Device Configuration Response” message may be used to respond to the broker manager’s upstream request for local devices; the packet may contain a list of all devices local to that subnet and their corresponding connection information (e.g., IP address, port, name, network, etc.). In some instances, the “Update Local Device Configuration” command is similar to the “Local Devices Configuration Request” except that it comes downstream from an upstream neighbor, and is a command for any broker manager that has a mediator in the specified subnet to reload its configuration for that subnet; this command may be sent if there is a change to the configured devices (e.g., change in the database), or it could also potentially be initiated in an ad hoc manner. In some cases, some broker managers may not include a configuration manager; typically, only the top-

level broker managers will have a configuration manager, but others may request configurations via command channels, or the like.

These and other functions of the example **300** (and its components) are described in greater detail below with respect to FIGS. **1**, **2**, and **4**.

FIGS. **4A-4J** (collectively, "FIG. **4**") are flow diagrams illustrating a method for implementing name-based routing through networks, in accordance with various embodiments. Method **400** of FIG. **4A** continues onto FIG. **4B** following the circular marker denoted, "A," and continues onto FIG. **4C** following the circular marker denoted, "B." Method **400** of FIG. **4B**, **4C**, **4H**, or **4I** continues onto FIG. **4E** following the circular marker denoted, "C." Method **400** of FIG. **4F** continues onto FIG. **4G** following the circular marker denoted, "D," and continues onto FIG. **4H** following the circular marker denoted, "E." Method **400** of FIG. **4G** continues onto FIG. **4I** following the circular marker denoted, "F."

While the techniques and procedures are depicted and/or described in a certain order for purposes of illustration, it should be appreciated that certain procedures may be reordered and/or omitted within the scope of various embodiments. Moreover, while the method **400** illustrated by FIG. **4** can be implemented by or with (and, in some cases, are described below with respect to) the systems, examples, or embodiments **100**, **200**, **200'**, and **300** of FIGS. **1**, **2A**, **2B**, and **3**, respectively (or components thereof), such methods may also be implemented using any suitable hardware (or software) implementation. Similarly, while each of the systems, examples, or embodiments **100**, **200**, **200'**, and **300** of FIGS. **1**, **2A**, **2B**, and **3**, respectively (or components thereof), can operate according to the method **400** illustrated by FIG. **4** (e.g., by executing instructions embodied on a computer readable medium), the systems, examples, or embodiments **100**, **200**, **200'**, and **300** of FIGS. **1**, **2A**, **2B**, and **3** can each also operate according to other modes of operation and/or perform other suitable procedures.

In the non-limiting embodiment of FIG. **4A**, method **400**, at block **402**, may comprise receiving, using a first broker manager that is disposed within a first network among a plurality of networks and from a first client device, a request to establish a connection with a first network device over at least one network among the plurality of networks. At block **404**, method may comprise determining, using the first broker manager, whether the first network device is listed within a stored list together with a connection path at least between the first broker manager and the first network device over the at least one network. If not, method **400** may continue onto the process at block **414** (whose flow is denoted by the dash-lined arrows between process blocks). If so, method **400** either may continue onto the process at block **406** (whose flow is denoted by the solid-lined arrows between process blocks) and/or may continue onto the process at block **420** in FIG. **4B** following the circular marker denoted, "A."

At block **406**, method **400** may comprise, based on a determination that the first network device is listed within the stored list together with a first connection path at least between the first broker manager and the first network device over the at least one network, sending or relaying, using the first broker manager, a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands. Method **400** may further comprise, at block **408**, receiving one or more commands for the first network device from the first client

device. Method **400** may further comprise, based on a determination that the first network device is not locally accessible by the first broker manager, and, in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via at least one of a local messaging broker or a downstream messaging broker that is managed by the first broker manager, based at least in part on a first connection path, without routing based on Internet Protocol ("IP") address of the first network device (block **410**), the first connection path comprising a name of the first network device and an identifier ("ID") of a second network within which the first network device is located. Alternatively, method **400** may further comprise, based on a determination that the first network device is locally accessible by the first broker manager, and, in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via the client broker and via a mediator broker over a second connection path, without routing based on IP address of the first network device (block **412**), the second connection path comprising a name of the first network device and an ID of the first network, the mediator broker being managed by the first broker manager.

At block **414**, method **400** may comprise forwarding, using the first broker manager, the request via at least one of the local messaging broker or the downstream messaging broker. Method **400** either may continue onto the process at block **416** and/or may continue onto the process at block **428** in FIG. **4C** following the circular marker denoted, "B." At block **416**, after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating at least one of that a third connection path exists between the first broker manager and the first network device or that the first network device has been found, sending, using the first broker manager, a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands, or the like. Method **400**, at block **418**, may comprise updating the stored list with the third connection path in association with the first network device by either the first broker manager or one of the at least one other broker manager. Method **400** may then continue onto the processes at blocks **408** and **410**. At block **410**, in particular, method **400** may comprise, in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands (via the client broker and) via the at least one of the local messaging broker or the downstream messaging broker, based at least in part on the third connection path, without routing based on IP address of the first network device, the third connection path comprising a name of the first network device and an ID of a third network within which the first network device is located.

In some embodiments, the first client device may be disposed within the first network. In some cases, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client device, the request via a client broker. In some instances, the local messaging broker may communicatively couple with a control channel associated with the first network. In some cases, the downstream messaging broker may communicatively couple with a control channel associated with one of the second network or an intermediate network among one

or more intermediate networks between the first network and the second network. In some instances, the ID of the second network comprises at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID of the second network, and/or the like. In some cases, each of the control channel associated with the first network, the control channel associated with the second network, and the control channel associated with the intermediate network may be clustered across multiple servers in its respective network.

In some instances, the mediator broker may comprise at least one of one or more serial line management (“SLM”) mediator brokers, one or more transmission control protocol (“TCP”) mediator brokers, one or more hypertext transfer protocol (“HTTP”) mediator brokers, one or more secure shell protocol (“SSH”) mediator brokers, or one or more simple network management protocol (“SNMP”) mediator brokers, and/or the like. In some cases, each of at least one SLM mediator broker among the one or more SLM mediator brokers may be configured to mediate multiple connections to multiple client devices regardless of whether the first network device to which it is communicatively coupled is only capable of single client-only connection. In some instances, one or more of the client broker, the local messaging broker, the downstream messaging broker, or the mediator broker that are managed by the first broker manager may be modular. In some cases, the client broker may be configured to be interchangeable with other client brokers, each messaging broker may be configured to be interchangeable with other messaging brokers, and the mediator broker may be configured to be interchangeable with other mediator brokers. In some instances, the first broker manager may be communicatively coupled to and may manage at least one of one or more client brokers, one or more messaging brokers, or one or more mediator brokers, and/or the like. In some cases, each client broker may comprise one of a single-port client broker that communicatively couples with a single client device or a multi-port client broker that communicatively couples with each of a plurality of client devices.

In some cases, the first client device may be disposed within a fourth network among the plurality of networks. In some instances, receiving the request to establish the connection with the first network device from the first client device may comprise receiving, using the first broker manager and from the first client device, the request via a second broker manager that is locally coupled with the first client device via its client broker and via an upstream messaging broker that is communicatively coupled with a control channel associated with one of the fourth network or an intermediate network among one or more intermediate networks between the first network and the fourth network, the upstream messaging broker being managed by the first broker manager. In some cases, sending or relaying the message to the first client device may comprise relaying, using the first broker manager, the message to the first client device via the upstream messaging broker and via the second broker manager. In some instances, routing the one or more commands may comprise routing, using the first broker manager, the one or more commands via at least one of the upstream messaging broker, the local messaging broker, or the downstream messaging broker, based at least in part on the first connection path, without routing based on IP address of the first network device.

According to some embodiments, the first connection path may further comprise one or more communications channels between the first broker manager and the first network device, the one or more communications channels

being joined by one or more intermediate broker managers between the first broker manager and the first network device. In some cases, the stored list may be maintained and updated within a network element database (“NED”). In some instances, the plurality of networks may be separated from each other by firewalls. Merely by way of example, in some cases, the first network device may comprise one of a network switch, an intermediary device, a multiservice provisioning platform, a gateway device, a network node, a router, a network security or firewall appliance, a telephone electronic switching system, an optical network switch and routing platform, a wavelength division multiplexing (“WDM”)—based optical transport network system, a network transmission system, a server, or a user device, and/or the like.

At block 420 in FIG. 4B (following the circular marker denoted, “A,” in FIG. 4A), method 400 may comprise determining, using the first broker manager, whether any alerts associated with the first network device have been received by an alert manager that is communicatively coupled with the first broker manager. Method 400, at block 422, may comprise performing at least one of the following, without polling other broker managers regarding the status of the first network device and without attempting to connect to the first network device via one or more brokers that are managed by the first broker manager: based on a determination that an alert has been received that indicates that the first network device is offline, sending or relaying, using the first broker manager, a message to the first client device indicating that the first network device is offline (block 424); or based on a determination that an alert has been received that indicates that a connection to the first network device is currently lost, sending or relaying, using the first broker manager, a message to the first client device indicating that a connection to the first network device is currently lost (block 426); and/or the like.

Method 400 may continue onto the process at block 442 in FIG. 4E following the circular marker denoted, “C.”

At block 428 in FIG. 4C (following the circular marker denoted, “B,” in FIG. 4A), method 400 may comprise, after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that the first network device is offline, updating, using the first broker manager, the stored list to indicate that the first network device is offline; and sending or relaying, using the first broker manager, a message to the first client device indicating that the first network device is offline (block 430). Alternatively, or additionally, method 400 (following the circular marker denoted, “B,” in FIG. 4A) may comprise, after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that a connection to the first network device is currently lost, updating, using the first broker manager, the stored list to indicate that a connection to the first network device is currently lost (block 432); and sending or relaying, using the first broker manager, a message to the first client device indicating that a connection to the first network device is currently lost (block 434).

Method 400 may continue onto the process at block 442 in FIG. 4E following the circular marker denoted, “C.”

Referring to FIG. 4D, in some embodiments, the stored list may comprise a subscription table associated with the first broker manager. In some cases, forwarding the request (at block 414) may comprise polling, using the first broker manager, at least one of the local messaging broker or the downstream messaging broker to determine whether a subscription for the first network device already exists (block

436). Method 400 may further comprise, at block 438, dynamically identifying and creating, using the first broker manager, subscriptions based at least in part on receiving one or more subscription acknowledgement (“sub ack”) messages from one or more intermediate broker managers between the first broker manager and the first network device in one or more of the first network, the third network, or an intermediate network among at least one intermediate network between the first network and the third network. Method 400 may further comprise autonomously filling, using the first broker manager, one or more subscription fields in the subscription table based on the identified and created subscriptions (block 440).

With reference to FIG. 4E, method 400 (following the circular marker denoted, “C,” in one of FIG. 4B, FIG. 4C, FIG. 4H, or FIG. 4I) may comprise at least one of: issuing, using the alert manager, a trouble ticket for the first network device (block 442); sending, using the alert manager, a message to a technician to repair at least one of the first network device or the connection to the first network device (block 444); sending, using the alert manager, an alert associated with the first network device to a fault management system (e.g., RFM 170 of FIG. 1, or the like) (block 446); or updating, using the first broker manager, the subscription table based at least in part on received status information associated with at least one of the first network device or the connection to the first network device (block 448); and/or the like.

In the non-limiting embodiment of FIG. 4F, method 400, at block 402', may comprise receiving, using a first broker manager that is disposed within a first network among a plurality of networks and from the first client device, a subscription request for subscribing to the first network device. At block 404', method may comprise determining, using the first broker manager, whether the first network device is listed within a subscription table. If not, method 400 may continue onto the process at block 436' in FIG. 4G following the circular marker denoted, “D.” If so, method 400 either may continue onto the process at block 406' and/or may continue onto the process at block 420' in FIG. 4H following the circular marker denoted, “E.”

At block 406', method 400 may comprise, based on a determination that the first network device is listed within the subscription table, sending or relaying, using the first broker manager, a message to the first client device indicating at least one of that a connection with the first network device has been established or that the first network device is ready to receive commands. In some embodiments, sending or relaying, using the first broker manager, the message to the first client device (at block 406') may comprise sending or relaying, using the first broker manager, a message to the first client device indicating at least one of a sub ack message, a message indicating that one or more publication/subscription (“pub/sub”) channels have been created for the first network device in at least the first network and the second network, or a message indicating that one or more intermediate broker managers between the first broker manager and the first network device have joined the one or more pub/sub channels.

Method 400 may further comprise, at block 408', receiving one or more commands for the first network device from the first client device. Method 400 may further comprise, based on a determination that the first network device is not locally accessible by the first broker manager, and, in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via at

least one of an upstream messaging broker, a local messaging broker, or a downstream messaging broker that is managed by the first broker manager, based at least in part on first subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device (block 410'), the first subscription data comprising a name of the first network device and an ID of a second network within which the first network device is located. Alternatively, method 400 may further comprise, based on a determination that the first network device is locally accessible by the first broker manager, and, in response to receiving the one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via the client broker and via a mediator broker based at least in part on second subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device (block 412'), the second subscription data comprising the name of the first network device and an ID of the first network, the mediator broker being managed by the first broker manager.

At block 436' in FIG. 4G (following the circular marker denoted, “D,” in FIG. 4F), method 400 may comprise polling, using the first broker manager, at least one of the upstream messaging broker, the local messaging broker, or the downstream messaging broker to determine whether a subscription for the first network device already exists. Method 400, at block 438', may comprise dynamically identifying and creating, using the first broker manager, subscriptions based at least in part on receiving one or more sub ack messages from one or more intermediate broker managers between the first broker manager and the first network device in one or more of the first network, a third network within which the first network device is determined to be located, or an intermediate network among at least one intermediate network between the first network and the third network. Method 400 may further comprise autonomously filling, using the first broker manager, one or more subscription fields in the subscription table based on the identified and created subscriptions (block 440'). Method 400 either may continue onto the process at block 450 and/or may continue onto the process at block 428' in FIG. 4I following the circular marker denoted, “F.”

At block 450, method 400 may comprise sending or relaying, using the first broker manager, a message to the first client device indicating at least one of a sub ack message, a message indicating that one or more pub/sub channels have been created for the first network device in at least the first network and the third network, or a message indicating that one or more intermediate broker managers between the first broker manager and the first network device have joined the one or more pub/sub channels. Method 400 may further comprise receiving one or more commands for the first network device from the first client device (block 452); and, in response to receiving one or more commands for the first network device from the first client device, routing, using the first broker manager, the one or more commands via at least one of the upstream messaging broker, the local messaging broker, or the downstream messaging broker, based at least in part on third subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device (block 454), the third subscription data comprising a name of the first network device and an ID of the third network within which the first network device is located.

At block **420'** in FIG. **4H** (following the circular marker denoted, "E," in FIG. **4F**), method **400** may comprise determining, using the first broker manager, whether any alerts associated with the first network device have been received by an alert manager that is communicatively coupled with the first broker manager. Method **400**, at block **422'**, may comprise performing at least one of the following, without polling other broker managers regarding the status of the first network device and without attempting to connect to the first network device via one or more brokers that are managed by the first broker manager: based on a determination that an alert has been received that indicates that the first network device is offline, sending or relaying, using the first broker manager, a first message to the first client device indicating that the first network device is offline (block **424'**); based on a determination that an alert has been received that indicates that a connection to the first network device is currently lost, sending or relaying, using the first broker manager, a second message to the first client device indicating that a connection to the first network device is currently lost (block **426'**); or based on a determination that the first network device is locally accessible by the first broker manager when the first network device is not offline and when the connection to the first network devices is not currently lost, sending at least one of the first message to the first client device indicating that the first network device is offline or the second message to the first client device indicating that a connection to the first network device is currently lost, without communicatively coupling with a mediator broker between the first broker manager and the first network device (block **456**), the mediator broker being managed by the first broker manager; and/or the like.

Method **400** may continue onto the process at block **442** in FIG. **4E** following the circular marker denoted, "C."

At block **428'** in FIG. **4I** (following the circular marker denoted, "F," in FIG. **4G**), method **400** may comprise, after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that the first network device is offline, updating, using the first broker manager, the subscription table to indicate that the first network device is offline; and sending or relaying, using the first broker manager, a message to the first client device indicating that the first network device is offline (block **430'**). Alternatively, or additionally, method **400** (following the circular marker denoted, "B," in FIG. **4A**) may comprise, after receiving a message from at least one other broker manager that is disposed within the plurality of networks indicating that a connection to the first network device is currently lost, updating, using the first broker manager, the subscription table to indicate that a connection to the first network device is currently lost (block **432'**); and sending or relaying, using the first broker manager, a message to the first client device indicating that a connection to the first network device is currently lost (block **434'**).

Method **400** may continue onto the process at block **442** in FIG. **4E** following the circular marker denoted, "C."

In the non-limiting embodiment of FIG. **4J**, method **400**, at block **402''**, may comprise receiving, using a broker manager among a first plurality of broker managers that is disposed within a first network among a plurality of networks and among a second plurality of broker managers that is disposed within a second network among the plurality of networks and from a first client device, a subscription request for subscribing to the first network device. Method **400** may comprise at least one of: adding subscription data that is associated with the first network device and that is contained in the subscription request to its respective sub-

scription table (block **458**), the subscription data comprising a name of the first network device and an identifier ("ID") of a second network within which the first network device is located; based on a determination that the first network device is not locally accessible, forwarding the subscription request to at least one of its respective local control channel via a local messaging broker that it manages or a downstream local control channel via a downstream messaging broker that it manages if elected as a primary publisher in its respective network (block **460**), and ignoring the subscription request if set as a secondary publisher in its respective network (block **462**), wherein the primary publisher in its respective network is elected by other broker managers in its respective network to perform pub/sub functions used in name-based routing, wherein the secondary publisher is on hot standby in its respective network to take over pub/sub functions during failover events involving the primary publisher; based on a determination that the first network device is locally accessible, creating one or more pub/sub channels in its respective local control channel (block **464**), and sending a sub ack message via at least one of an upstream messaging broker that it manages or the local messaging broker that it manages (block **466**); in response to receiving the sub ack message from another broker manager, joining the one or more pub/sub channels and forwarding the sub ack message to a local control channel in an upstream network if elected as a primary publisher in its respective network (block **468**), and joining the one or more pub/sub channels and ignoring the sub ack message if set as a secondary publisher in its respective network (block **470**); if the first client device is locally accessible to it, sending confirmation of subscription to the first client device via a client broker that it manages (block **472**), and receiving and routing one or more commands for the first network device from the first client device via the client broker and via at least one of the local messaging broker, a downstream messaging broker, or a mediator broker that it manages, based at least in part on the subscription data, without routing based on IP address of the first network device (block **474**); and/or the like.

Exemplary System and Hardware Implementation

FIG. **5** is a block diagram illustrating an exemplary computer or system hardware architecture, in accordance with various embodiments. FIG. **5** provides a schematic illustration of one embodiment of a computer system **500** of the service provider system hardware that can perform the methods provided by various other embodiments, as described herein, and/or can perform the functions of computer or hardware system (i.e., computing systems **105a105n** and **105a'-105n'**, broker managers **110a110n**, **110a'-110n'**, **210**, **210a**, **210b**, **310a**, **310b**, **310c**, **310d**, **310x**, and **310y**, client brokers **115a-115n**, **215**, **215a215n**, and **C**, messaging brokers **120a120c**, **220a220c**, **U**, **L**, and **D**, mediator brokers **125a-125n**, **225a225n**, and **M**, subscription tables **130**, **230**, and **S**, alert managers **135**, **235**, and **A**, client devices **145a-145n**, **245a245c**, and **345**, network element database ("NED") **150** and **350**, network devices **155a-155n**, **255a255d**, and **355**, firewalls **160**, **260**, and **360**, control channels **165** and **365a365c**, real-time fault management system ("RFM") **170**, intermediate devices **280a280d**, device send channels **385a385c** and device receive channels **390a390c**, etc.), as described above. It should be noted that FIG. **5** is meant only to provide a generalized illustration of various components, of which one or more (or none) of each may be utilized as appropriate. FIG. **5**, therefore, broadly

illustrates how individual system elements may be implemented in a relatively separated or relatively more integrated manner.

The computer or hardware system **500**—which might represent an embodiment of the computer or hardware system (i.e., computing systems **105a105n** and **105a'-105n'**, broker managers **110a110n**, **110a'-110n'**, **210**, **210a**, **210b**, **310a**, **310b**, **310c**, **310d**, **310x**, and **310y**, client brokers **115a-115n**, **215**, **215a215n**, and **C**, messaging brokers **120a120c**, **220a220c**, **U**, **L**, and **D**, mediator brokers **125a-125n**, **225a225n**, and **M**, subscription tables **130**, **230**, and **S**, alert managers **135**, **235**, and **A**, client devices **145a-145n**, **245a245c**, and **345**, **NED 150** and **350**, network devices **155a-155n**, **255a255d**, and **355**, firewalls **160**, **260**, and **360**, control channels **165** and **365a365c**, **RFM 170**, intermediate devices **280a280d**, device send channels **385a385c** and device receive channels **390a390c**, etc.), described above with respect to FIGS. 1-4—is shown comprising hardware elements that can be electrically coupled via a bus **505** (or may otherwise be in communication, as appropriate). The hardware elements may include one or more processors **510**, including, without limitation, one or more general-purpose processors and/or one or more special-purpose processors (such as microprocessors, digital signal processing chips, graphics acceleration processors, and/or the like); one or more input devices **515**, which can include, without limitation, a mouse, a keyboard, and/or the like; and one or more output devices **520**, which can include, without limitation, a display device, a printer, and/or the like.

The computer or hardware system **500** may further include (and/or be in communication with) one or more storage devices **525**, which can comprise, without limitation, local and/or network accessible storage, and/or can include, without limitation, a disk drive, a drive array, an optical storage device, solid-state storage device such as a random access memory (“RAM”) and/or a read-only memory (“ROM”), which can be programmable, flash-updateable, and/or the like. Such storage devices may be configured to implement any appropriate data stores, including, without limitation, various file systems, database structures, and/or the like.

The computer or hardware system **500** might also include a communications subsystem **530**, which can include, without limitation, a modem, a network card (wireless or wired), an infra-red communication device, a wireless communication device and/or chipset (such as a Bluetooth™ device, an 802.11 device, a WiFi device, a WiMax device, a WWAN device, cellular communication facilities, etc.), and/or the like. The communications subsystem **530** may permit data to be exchanged with a network (such as the network described below, to name one example), with other computer or hardware systems, and/or with any other devices described herein. In many embodiments, the computer or hardware system **500** will further comprise a working memory **535**, which can include a RAM or ROM device, as described above.

The computer or hardware system **500** also may comprise software elements, shown as being currently located within the working memory **535**, including an operating system **540**, device drivers, executable libraries, and/or other code, such as one or more application programs **545**, which may comprise computer programs provided by various embodiments (including, without limitation, hypervisors, VMs, and the like), and/or may be designed to implement methods, and/or configure systems, provided by other embodiments, as described herein. Merely by way of example, one or more procedures described with respect to the method(s) dis-

cussed above might be implemented as code and/or instructions executable by a computer (and/or a processor within a computer); in an aspect, then, such code and/or instructions can be used to configure and/or adapt a general purpose computer (or other device) to perform one or more operations in accordance with the described methods.

A set of these instructions and/or code might be encoded and/or stored on a non-transitory computer readable storage medium, such as the storage device(s) **525** described above. In some cases, the storage medium might be incorporated within a computer system, such as the system **500**. In other embodiments, the storage medium might be separate from a computer system (i.e., a removable medium, such as a compact disc, etc.), and/or provided in an installation package, such that the storage medium can be used to program, configure, and/or adapt a general purpose computer with the instructions/code stored thereon. These instructions might take the form of executable code, which is executable by the computer or hardware system **500** and/or might take the form of source and/or installable code, which, upon compilation and/or installation on the computer or hardware system **500** (e.g., using any of a variety of generally available compilers, installation programs, compression/decompression utilities, etc.) then takes the form of executable code.

It will be apparent to those skilled in the art that substantial variations may be made in accordance with specific requirements. For example, customized hardware (such as programmable logic controllers, field-programmable gate arrays, application-specific integrated circuits, and/or the like) might also be used, and/or particular elements might be implemented in hardware, software (including portable software, such as applets, etc.), or both. Further, connection to other computing devices such as network input/output devices may be employed.

As mentioned above, in one aspect, some embodiments may employ a computer or hardware system (such as the computer or hardware system **500**) to perform methods in accordance with various embodiments of the invention. According to a set of embodiments, some or all of the procedures of such methods are performed by the computer or hardware system **500** in response to processor **510** executing one or more sequences of one or more instructions (which might be incorporated into the operating system **540** and/or other code, such as an application program **545**) contained in the working memory **535**. Such instructions may be read into the working memory **535** from another computer readable medium, such as one or more of the storage device(s) **525**. Merely by way of example, execution of the sequences of instructions contained in the working memory **535** might cause the processor(s) **510** to perform one or more procedures of the methods described herein.

The terms “machine readable medium” and “computer readable medium,” as used herein, refer to any medium that participates in providing data that causes a machine to operate in a specific fashion. In an embodiment implemented using the computer or hardware system **500**, various computer readable media might be involved in providing instructions/code to processor(s) **510** for execution and/or might be used to store and/or carry such instructions/code (e.g., as signals). In many implementations, a computer readable medium is a non-transitory, physical, and/or tangible storage medium. In some embodiments, a computer readable medium may take many forms, including, but not limited to, non-volatile media, volatile media, or the like. Non-volatile media includes, for example, optical and/or magnetic disks, such as the storage device(s) **525**. Volatile

media includes, without limitation, dynamic memory, such as the working memory 535. In some alternative embodiments, a computer readable medium may take the form of transmission media, which includes, without limitation, coaxial cables, copper wire, and fiber optics, including the wires that comprise the bus 505, as well as the various components of the communication subsystem 530 (and/or the media by which the communications subsystem 530 provides communication with other devices). In an alternative set of embodiments, transmission media can also take the form of waves (including without limitation radio, acoustic, and/or light waves, such as those generated during radio-wave and infra-red data communications).

Common forms of physical and/or tangible computer readable media include, for example, a floppy disk, a flexible disk, a hard disk, magnetic tape, or any other magnetic medium, a CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read instructions and/or code.

Various forms of computer readable media may be involved in carrying one or more sequences of one or more instructions to the processor(s) 510 for execution. Merely by way of example, the instructions may initially be carried on a magnetic disk and/or optical disc of a remote computer. A remote computer might load the instructions into its dynamic memory and send the instructions as signals over a transmission medium to be received and/or executed by the computer or hardware system 500. These signals, which might be in the form of electromagnetic signals, acoustic signals, optical signals, and/or the like, are all examples of carrier waves on which instructions can be encoded, in accordance with various embodiments of the invention.

The communications subsystem 530 (and/or components thereof) generally will receive the signals, and the bus 505 then might carry the signals (and/or the data, instructions, etc. carried by the signals) to the working memory 535, from which the processor(s) 505 retrieves and executes the instructions. The instructions received by the working memory 535 may optionally be stored on a storage device 525 either before or after execution by the processor(s) 510.

While certain features and aspects have been described with respect to exemplary embodiments, one skilled in the art will recognize that numerous modifications are possible. For example, the methods and processes described herein may be implemented using hardware components, software components, and/or any combination thereof. Further, while various methods and processes described herein may be described with respect to particular structural and/or functional components for ease of description, methods provided by various embodiments are not limited to any particular structural and/or functional architecture but instead can be implemented on any suitable hardware, firmware and/or software configuration. Similarly, while certain functionality is ascribed to certain system components, unless the context dictates otherwise, this functionality can be distributed among various other system components in accordance with the several embodiments.

Moreover, while the procedures of the methods and processes described herein are described in a particular order for ease of description, unless the context dictates otherwise, various procedures may be reordered, added, and/or omitted in accordance with various embodiments. Moreover, the procedures described with respect to one method or process may be incorporated within other described methods or

processes; likewise, system components described according to a particular structural architecture and/or with respect to one system may be organized in alternative structural architectures and/or incorporated within other described systems. Hence, while various embodiments are described with—or without—certain features for ease of description and to illustrate exemplary aspects of those embodiments, the various components and/or features described herein with respect to a particular embodiment can be substituted, added and/or subtracted from among other described embodiments, unless the context dictates otherwise. Consequently, although several exemplary embodiments are described above, it will be appreciated that the invention is intended to cover all modifications and equivalents within the scope of the following claims.

What is claimed is:

1. A system, comprising:

a first plurality of broker managers disposed within a first network among a plurality of networks, the plurality of networks being separated from each other by firewalls; a second plurality of broker managers disposed within a second network among the plurality of networks; and a first network device among a plurality of network devices, the first network device being disposed in the second network;

wherein:

in response to receiving a subscription request from a first client device for subscribing to the first network device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers is configured to perform at least one of:

adding subscription data that is associated with the first network device and that is contained in the subscription request to its respective subscription table, the subscription data comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located;

based on a determination that the first network device is not locally accessible, forwarding the subscription request to at least one local control channel via a messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the subscription request if set as a secondary publisher in its respective network; or

based on a determination that the first network device is locally accessible, creating one or more publication/subscription (“pub/sub”) channels in its respective local control channel, and sending a subscription acknowledgement (“sub ack”) message via the messaging broker that it manages.

2. The system of claim 1, wherein:

in response to receiving the subscription request from a first client device for subscribing to the first network device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers is further configured to perform at least one of:

in response to receiving the sub ack message from another broker manager, joining the one or more pub/sub channels, forwarding the sub ack message to a local control channel in an upstream network if elected as a primary publisher in its respective network, and ignoring the sub ack message if set as a secondary publisher in its respective network; or

if the first client device is locally accessible to it, sending confirmation of subscription to the first client device via a client broker that it manages, and receiving and routing one or more commands for the first network device from the first client device via the client broker and via at least one of the messaging broker or a mediator broker that it manages, based at least in part on the subscription data, without routing based on Internet Protocol (“IP”) address of the first network device.

3. The system of claim 2, wherein:

each broker manager receiving the subscription request comprises each broker manager receiving the subscription request via at least one of a client broker or the messaging that it manages;

the messaging broker for each broker manager (i) communicatively couples with a control channel associated with its respective network, (ii) communicatively couples with a control channel associated with one of its respective network or a downstream intermediate network among one or more downstream intermediate networks between its respective network and the second network, or (iii) communicatively couples with a control channel associated with one of a fourth network within which the client device is disposed if not disposed in the first network or an upstream intermediate network among one or more upstream intermediate networks between the first network and the fourth network, in the case that the first network is disposed between the fourth network and the second network;

the ID of the second network comprises at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID of the second network; and

the mediator broker comprises at least one of one or more serial line management (“SLM”) mediator brokers, one or more transmission control protocol (“TCP”) mediator brokers, one or more hypertext transfer protocol (“HTTP”) mediator brokers, one or more secure shell protocol (“SSH”) mediator brokers, or one or more simple network management protocol (“SNMP”) mediator brokers.

4. The system of claim 3, wherein each of at least one SLM mediator broker among the one or more SLM mediator brokers is configured to mediate multiple connections to multiple client devices regardless of whether the first network device to which it is communicatively coupled is only capable of single client-only connection.

5. The system of claim 3, wherein one or more of the client broker, the messaging broker, or the mediator broker are modular, wherein the client broker is configured to be interchangeable with other client brokers, the messaging broker is configured to be interchangeable with other messaging brokers, and the mediator broker is configured to be interchangeable with other mediator brokers, wherein each broker manager is communicatively coupled to and manages at least one of one or more client brokers, one or more messaging brokers, or one or more mediator brokers, wherein each client broker comprises one of a single-port client broker that communicatively couples with a single client device or a multi-port client broker that communicatively couples with each of a plurality of client devices.

6. The system of claim 1, wherein each subscription table associated a corresponding broker manager among the first plurality of broker managers and among the second plurality of broker managers is maintained and updated within a network element database (“NED”).

7. The system of claim 1, wherein the first network device comprises one of a network switch, an intermediary device, a multiservice provisioning platform, a gateway device, a network node, a router, a network security or firewall appliance, a telephone electronic switching system, an optical network switch and routing platform, a wavelength division multiplexing (“WDM”) -based optical transport network system, a network transmission system, a server, or a user device.

8. The system of claim 1, further comprising:

a first local control channel disposed in the first network; and

a second local control channel disposed in the second network;

wherein:

each of the first local control channel and the second local control channel is clustered across multiple servers in its respective network; and

a second primary broker manager communicatively couples with the first network device via its mediator broker.

9. The system of claim 8, wherein:

the first client device is disposed within the first network; a first primary broker manager communicatively couples with the first client device via its client broker;

the first primary broker manager communicatively couples with the first local control channel via its local messaging broker; and

the first primary broker manager communicatively couples with the second local control channel via its downstream messaging broker.

10. The system of claim 9, further comprising:

a third plurality of broker managers disposed within a third network among the plurality of networks, the third network being a downstream intermediate network among one or more downstream intermediate networks between the first network and the second network; and a third local control channel disposed in the third network; wherein the first primary broker manager communicatively couples with a second local control channel, via a third local control channel and via its downstream messaging broker.

11. The system of claim 8, further comprising:

a fourth plurality of broker managers disposed within a fourth network among the plurality of networks; and a fourth local control channel disposed in the fourth network;

wherein:

the first client device is disposed within the fourth network;

a first primary broker manager communicatively couples with the first client device via the fourth local control channel, via the fourth primary broker manager, and via its upstream messaging broker;

the first primary broker manager communicatively couples with the first local control channel via its local messaging broker; and

the first primary broker manager communicatively couples with the second local control channel via its downstream messaging broker.

12. The system of claim 11, further comprising:

a fifth plurality of broker managers disposed within a fifth network among the plurality of networks, the fifth network being an upstream intermediate network among one or more upstream intermediate networks between the first network and the fourth network; and a fifth local control channel disposed in the fifth network;

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wherein the first primary broker manager communicatively couples with the fourth local control channel via the fifth local control channel and via its upstream messaging broker.

13. The system of claim 1, wherein:

in response to receiving one or more commands for the first network device from the first client device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers is further configured to perform at least one of:

based on a determination that the first network device is not locally accessible, routing the one or more commands to at least one of its local control channel via its messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the one or more commands if set as a secondary publisher in its respective network; or based on a determination that the first network device is locally accessible, routing the one or more commands to the first network device via its mediator broker; and

routing the one or more commands is based at least in part on subscription data associated with the first network device that is contained in the subscription table, without routing based on IP address of the first network device.

14. The system of claim 13, wherein:

in response to receiving a reply from the first network device for the first client device, each broker manager among the first plurality of broker managers and among the second plurality of broker managers is further configured to perform at least one of:

based on a determination that the first client device is not locally accessible, routing the reply to at least one of its local control channel via the messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the reply if set as a secondary publisher in its respective network; or based on a determination that the first client device is locally accessible, routing the reply to the first client device via its client broker.

15. The system of claim 1, wherein:

after it initializes or powers on, each broker manager among the first plurality of broker managers and among the second plurality of broker managers is further configured to perform at least one of:

initializing one or more mediator brokers it is managing; initializing one or more client brokers it is managing; connecting to at least one of its local control channel via the messaging broker that it manages; sending a hello message over at least one of its local control channel; or

in response to receiving a hello acknowledgement (“hello ack”) message from each of one or more broker managers among the first plurality of broker managers and among the second plurality of broker managers, marking presence of each of the one or more broker managers.

16. The system of claim 1, wherein each broker manager among the first plurality of broker managers and among the second plurality of broker managers comprises at least one of a virtual broker manager, a software-based (“SW”) broker manager, or a broker manager software application (“app”).

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17. A method, comprising:

in response to receiving a subscription request from a first client device for subscribing to a first network device, a broker manager performing at least one of the following, the broker manager being among a first plurality of broker managers that is disposed within a first network among a plurality of networks and among a second plurality of broker managers that is disposed within a second network among the plurality of networks, the plurality of networks being separated from each other by firewalls:

adding subscription data that is associated with the first network device and that is contained in the subscription request to its respective subscription table, the subscription data comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located;

based on a determination that the first network device is not locally accessible, forwarding the subscription request to at least one of its local control channel via a messaging broker that it manages if elected as a primary publisher in its respective network, and ignoring the subscription request if set as a secondary publisher in its respective network; or

based on a determination that the first network device is locally accessible, creating one or more publication/subscription (“pub/sub”) channels in its local control channel, and sending a subscription acknowledgement (“sub ack”) message via the messaging broker that it manages.

18. The method of claim 17, further comprising:

in response to receiving the subscription request from the first client device for subscribing to the first network device, the broker manager further performs at least one of the following:

in response to receiving the sub ack message from another broker manager, a local control channel in an upstream network if elected as a primary publisher in its respective network, and ignoring the sub ack message if set as a secondary publisher in its respective network; or

if the first client device is locally accessible to it, sending confirmation of subscription to the first client device via a client broker that it manages, and receiving and routing one or more commands for the first network device from the first client device via the client broker and via the messaging or a mediator broker that it manages, based at least in part on the subscription data, without routing based on Internet Protocol (“IP”) address of the first network device.

19. The method of claim 18, wherein:

receiving the subscription request comprises the broker manager receiving the subscription request via at least one of a client broker, or the messaging broker that it manages;

the messaging broker for each broker manager (i) communicatively couples with a control channel associated with its respective network, (ii) communicatively couples with a control channel associated with one of its respective network or a downstream intermediate network among one or more downstream intermediate networks between its respective network and the second network, or (iii) communicatively couples with a control channel associated with one of a fourth network within which the client device is disposed if not disposed in the first network or an upstream intermediate network among one or more upstream intermediate

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networks between the first network and the fourth network, in the case that the first network is disposed between the fourth network and the second network; the ID of the second network comprises at least one of a name, an alphanumeric ID, a numeric ID, or a unique ID of the second network; and

the mediator broker comprises at least one of one or more serial line management (“SLM”) mediator brokers, one or more transmission control protocol (“TCP”) mediator brokers, one or more hypertext transfer protocol (“HTTP”) mediator brokers, one or more secure shell protocol (“SSH”) mediator brokers, or one or more simple network management protocol (“SNMP”) mediator brokers.

20. A system, comprising:

- a first plurality of broker managers disposed within a first network among a plurality of networks, the plurality of networks being separated from each other by firewalls;
- a second plurality of broker managers disposed within a second network among the plurality of networks;
- a first network device among a plurality of network devices, the first network device being disposed in the second network; and
- a computing system that is disposed within one of the plurality of networks, the computing system comprising:
 - a broker manager among the first plurality of broker managers and among the second plurality of broker managers;
 - at least one first processor; and
 - a first non-transitory computer readable medium communicatively coupled to the at least one first proces-

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sor, the first non-transitory computer readable medium having stored thereon computer software comprising a first set of instructions that, when executed by the at least one first processor, causes the broker manager to:

in response to receiving a subscription request from a first client device for subscribing to the first network device,

- add subscription data that is associated with the first network device and that is contained in the subscription request to its respective subscription table, the subscription data comprising a name of the first network device and an identifier (“ID”) of a second network within which the first network device is located;
- based on a determination that the first network device is not locally accessible, forward the subscription request to at least one of its local control channel via a messaging broker that it manages if elected as a primary publisher in its respective network, and ignore the subscription request if set as a secondary publisher in its respective network; or
- based on a determination that the first network device is locally accessible, create one or more publication/subscription (“pub/sub”) channels in its respective local control channel, and send a subscription acknowledgement (“sub ack”) message via the messaging broker that it manages.

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